MENSURATION IN ANCIENT INDIA

SARADHA SRINIVASAN

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Foreword

THE interesting human experience of using the materials of the world requires measuring length, area, volumes, weights etc. This need was satisfied by all cultural groups in a variety of ways in which fingers, hands, body length, weights of grains, etc., were used.

This activity, developed systems of mensurations over the whole world and they were used to measure the objects and form standardised patterns of human behaviour for transactions of trade, commerce, division of property, paying for labour, measuring time, etc., in different times and areas.

In India also, this effort of standardization of mensurations has a long history. In this effort many experiments were made and many systems were developed. Mrs. Srinivasan has taken great care in analysing these systems of measuring length, area volume, weight and time by the study of written and archaeological data. Besides, she has compared the local practices that were existing till recently and some that continue to exist.

Besides, the comparison of the mensurations of different countries, she has given a succinct account of the common elements of this branch of human activity.

Her work, therefore, fulfils a long standing requirement in this field. It will be an useful work for archaeologists and historians and also will provide an extremely interesting reading to the general reader.

—R. N. Mehta

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Preface

IN recent years a good number of monographs have come up on the economic history of ancient India, but no work has so far been published on an important aspect of this economic history, namely the weights and measures of ancient India. This work aims in filling that need.

In a large number of works in ancient India on political science, mathematics and astronomy, certain aspects of weights and measures have been described. The present work deals with gathering of all those materials along with the references in epigraphs and correlate them with the weights and measures mentioned in the literature of the other civilizations relating to that period.

I am deeply indebted to Dr. R.N. Mehta, Head, Department of Archaeology, Maharaja Sayajirao University, Baroda, whose encouragement and inspiring guidance made it possible to plan and complete this work. I would like to record my humble gratitude to him for the interest he took in guiding me through.

I offer my thanks to the artists of the department of Archaeology, M. S. University of Baroda, for preparing the charts and photographs.

Numerous scholars have contributed directly or indirectly on this subject and I have drawn extensively from their works. I express my thanks to all those scholars, whom I have quoted in this study.

I am thankful to Mr. S. Balwant, proprietor, Ajanta Books International for having taken a personal interest in printing and publishing this book.

10-11-78 —Saradha Srinivasan

Contents

Abbreviations

AGAS	Andhra Pradesh Government Archaeological Series
BSOAC	Bulletin of the School of Oriental and African Studies
CBI	Corpus of Bengal Inscriptions
CII	Corpus Inscriptionum Indicarum
EC	Epigraphia Carnatica
EI	Epigraphia Indica
HAS	Hyderabad Archaeological Series
IA	Indian Antiquary
IC	Indian Culture
IE	Indian Epigraphy
IHQ	Indian Historical Quarterly
JASB	Journal of the Asiatic Society of Bengal
JAHRS	Journal of the Andhra Historical Research Society
JBBRAS	Journal of the Bombay Branch of Royal Asiatic Society
JBRS	Journal of the Bihar Research Society
JIH	Journal of Indian History
JMSUB	Journal of the Maharaja Sayajirao University of Baroda
JNSI	Journal of the Numismatic Society of India
JOIB	Journal of the Oriental Institute, Baroda
JRAS	Journal of the Royal Asiatic Society
JTSML	Journal of the Tanjore Saraswati Mahal Library
KI	Karnataka Inscriptions
MASR	Mysore Archaeological Survey Reports
MAER	Madras Annual Epigraphical Reports
NDI	Nellore District Inscriptions
QJMS	Quarterly Journal of Mythic Society
SII	South Indian Inscriptions

1

Introduction

A STUDY of the evolution of measures and weights in any civilization constitutes one of the important parameters for assessing and understanding its growth. For example, even today the ancient Egypt is remembered for its contributions to astronomy, while ancient Greek and Roman civilizations are remembered, for setting the foundations of modern mathematical standards and for the development of currency as means for transacting trade and business. The very evolution of economic history of a civilization gets intimately linked with the growth of its weights, measures and coinage.

For the primitive man and even animals, the earliest concepts relating to measurements would be in relation to distances and sizes of objects, which would serve to help him in his day-to-day activities. A monkey will have to understand the distance to jump across and also will have to have the concept of the size of other animals to decide to fight or flee. Thus this basic need, as the knowledge of man increased, led to the ideas on linear measurements, weight, volume, etc.

Similarly, with the needs of lifting materials such as carrying food or prey, lifting of materials for building shelter or carrying firewood, etc., ideas about relative weights of objects must have evolved, which further would have led to standardized weights and measures for promotion of trade and

business transactions. This should have progressed to the designing of more and more sophisticated instruments for weighing such as balances and weights. The older methods of barter system for transactions proved to be cumbersome and difficult, particularly, while dealing with heavy objects and products that can decay. This naturally, led to the development of coinage system, which has now become the backbone of all economic activities. The study of the extent to which these systems got evolved due to internal capabilities and the extent of outside influences on these systems can go a long way to understand not only the growth of the civilization of a nation, but also can contribute to assess the impact of its international relationships through the ages.

In India, even though many studies have been made in relation to currency in ancient India, no serious study appears to have been made to trace the evolution of measures and weights. It was, therefore, considered worthwhile to critically examine the old literature and epigraphical references, with a view to trace the evolution of concepts of measures and weights in ancient India and also to compare these developments along with the contemporary developments in other known ancient civilizations.

A brief examination of this subject relating to western India, through the period 7th century A.D. to early 14th century A.D., formed a small part of Ph.D. thesis presented by the author to the M.S. University of Baroda.

Even though, that study was restricted to a small part of India over a limited period, it revealed the fact, that different regions in India had different types of units of measures and weights, and that they also differed from period to period linked with changing dynasties, rather than to a standardized commercial system. This variety and fluctuations noticed in this earlier study, led to the belief that the concept of measures and weights in India had many differences and variations in different parts of the country at different periods. All the same, there had been a flourishing trade existing within the country and also with traders from abroad. Such commercial contacts, should have brought about certain common features in the concepts of measures and weights in the country as a whole,

which are examined here. To a large extent this evolution appears to be linked with the growth of mathematics as a discipline. The great contributions made in the field of astronomy in ancient India also indicate the advances made in India in terms of measurements of time, stellar movements, distances between planets, their movements, etc.

In India, just as in all other phases of activities, even in relation to measures and weights, there appears to have existed an undercurrent of unity in diversity. This aspect also has been considered in this work.

A brief account relating to the study on measures and weights in ancient India will be relevant to understand the scope of this work.

Measures and weights have an older history than that of currency. Excavations at the Indus valley have disclosed various types of weights current in India, during the 3rd millennium B.C. The term *pramāṇa* meaning measure was classified into four types namely, *māna* (measure of capacity) *tulā māna* (measure by weight), *avamāna* (linear measurement) and *kāla pramāṇa* (measurement of time). Vedic measures were simple, meeting the needs of day-to-day-life. For linear measurements, different parts of human body were regarded as units. A man's stride was known as *prakramá*. By the same way, for the measure of capacity *prasṛti*, meaning a handful, was used. Similarly *añjali* meaning two hands joined together which was double of *prasṛti* was also in common use.

Later on these simple practical units were further developed. Śulva sūtra portion of *Dharmasūtras* refers to a variety of linear and area measurements.

Kauṭilya describes several kinds of balances, thereby showing the appreciation for the need of accuracy in weighing even in early times. Several tables were used for measuring gold, silver and other articles. For the sake of convenience, cubic measures were also used for measuring out grains. Manu, Yājñavalkya and later on Vijñāneśwara followed almost the same systems of Kauṭilya, with slight variations.

Astronomical and astrological books, which were abundant in ancient India, furnish tables for measurements of space and time. Aryabhaṭa I (born in 476 A.D.) in his *Āryabhaṭīya*, has

allotted a chapter on mensuration called *ganita pāda*. Varāhamihira refers to mensuration in his *Bṛhatsaṁhita*. There is a similar chapter in *Brahmasphutasiddhānta* (628 A.D.) of Brahmagupta. While commenting on it, Pruthudakasvāmin (860 A.D.) added mathematical details to the original. The greatest luminary Bhāskarācārya refers to *Pāṭigaṇita* in *Siddhānta Śiromaṇi* (1150 A.D.). In his astrological work *Karanakutūhala* various terms relating to time occur. Jains did not lag behind in astronomical and astrological works. *Bhagavatisūtra* (5th arya) and *Uttarādhyayanasūtra* inform us that knowledge of sānkhyana (arithmetic) and jyotiṣa are two of the essential accomplishments of a Jaina saint. These subjects formed a part of his training. The most important sources for Indian weights and measures are the works on mathematics. Pāṭigaṇita is the name given to that branch of Indian mathematics which deals with arithmetic and mensuration. Lalla (8th century A.D.) wrote the work *Pāṭigaṇita*. Mahāvīra's *Gaṇitasārasangraha* is an important treatise on mathematics. *Pāṭigaṇita* of Śrīdharācārya was written somewhere between 850 A.D. and 950 A.D.

The author of another *Pātigaṇita* is Anantapāla, brother of Dhanapāla (12th century A.D.). *Gaṇitatilaka* or *Pāṭigaṇita* of Śrīpati is another important mathematical work of 11th century A.D. Bhāskarācārya's *Līlāvati* has a table for measures and weights which was adopted in that work. These must have been current in his time. Many mathematicians have exerted themselves in commenting upon *Līlāvati*. It was even translated into Persian by Fayzi under Akbar. In Takhura Pheru's *Gaṇitasārakaumudi* and *Dravyaparīkṣā*, written in Prakrit, it refers to weights, measures and coinage. Besides these, there are certain Kannaḍa works on mathematics and astrology. Śrīdharācārya (1049 A.D.) had composed in Kannaḍa *Jātakatilaka*. Rājāditya (1120 A.D.) was the author of six works namely (1) *Vyavahāra gaṇita* (in mixed prose and poetry) (2) *Kṣetra gaṇita* (in poetry), (3) *Vyavahāra ratna*, (4) *Līlāvati* (5) *Jaina gaṇita sutrodāharaṇa* and (6) *Citrahasuge*.

In the Gujarati commentary on *Gaṇitasāra* of Śrīdhara, along with the measures and weights given in the mathematical works, local weights and measures used in day-to-day transactions are also given.

The medical books like *Caraka saṁhita*, *Suśrutā saṁhitā* and *Sārangadhara saṁhitā* refer to many cubic measures. Tables regarding linear measurements occur in *Samarānganasūtradhāra*, *Aparājitapṛccha*, *Viśwakarmā*, *Vāstuśāstram* and *Mayamatam*. In these works, the different types of *aṅgulas* and their usages are explained.

In addition to these, the renowned fragmentary Bakṣali manuscript, written in Prakrit on birchbark in the Sarda script, discovered in 1881 A.D., furnishes interesting data about weights, measures and currency of ancient India. There are other manuscripts regarding astronomy, astrology and mathematics which have not yet been published. These may furnish many interesting data. There are some scattered references to weights and measures in the inscriptions also.

The very fact, that falsification of weights and measures was considered as a cognizable offence by the Dharmaśāstras, clearly indicates the existence of a well-controlled system for the maintenance of standards relating to weights and measures in ancient times. In addition to these, the examination of Dravidian literature and the literature of Bengal also lead to interesting information, which also is included in this work.

The various literary and epigraphic data relating to measures and weights in India through different ages and in different parts are presented in this treatise with a view to examine the evolution of the concepts relating to measures and weights and also to see to what extent an undercurrent of linkage and unity existed in all these in the wide diversity that was apparent.

2

Linear Measures of Ancient India

QUITE early in history, man took to measuring various things. Of the various types of measures, the linear measures had an earlier origin, because man would require to cut sticks of required sizes, or chop fruits or meat of required lengths, etc. For such purposes, he could use the parts of his own body as the standards, for that would measure the length which is always a distance between two points. Length could be defined by some natural or artificial standards or as multiples of those standards. A close look at the early linear measurements indicates, that the units of linear measurements used, were mainly derived from the parts of the human body all over the world. The finger, the palm or hand-breadth, the foot and the cubit were the principal measures. These natural units, eventhough had their limited uses to meet the needs of the ancient man, suffered from lack of standardized accuracy required for settling disputes or manufacturing standardized materials or parts thereof. The variations of human body are obvious and therefore for standardization at a later stage the body measurements of some particular person, were considered as the units of measuring in a particular area, so that the measurements at least in that area can become more standardized. Often these standards based upon the measurements of a person (a ruler, or the headman or the deity in the

local temple) were a matter of sentiment, but once accepted they helped to meet local exigencies and served the limited purpose for which they were created.

In view of the great variations in the actual values of these natural measures and also in view of the increasing interest in precise astronomical and geodetic measurements, as the civilizations progressed, more precise standardization of the linear measurements became necessary. Prototype-physical standards appear to have been devised and placed in temples or other places, where they could remain secure and be used as standard references.

The use of standardized measuring rods, scales and reeds appear to have been in vogue in India and other parts of the world from very ancient period. The oldest reference to the use of measuring rod for measuring or surveying a field in ancient India is seen in Ṛg Veda.[1] The finding of a slip of measuring scale made of shell from Mohenjo Daro[2], an ivory scale from Lothal[3], a fragmentary rod at Harappa[4] and another from Kālibangan[5], assert the use of measuring scales in ancient India. Similarly, graduated scales can be seen from the Sankereh tablets of Babylon (2500 B.C.)[6] and also from the ruins of the ancient city of Lagash or Lagas.[7] Ezekiel (600 B.C.), who wrote in Babylon, mentions the measuring of the tabernacle with reeds.[8] The Egyptians attempted to delineate the property lines, obliterated by the repeated floodings of the river Nile, through their Nilometer.[9] These clearly indicate that through ages man had attempted to improve his methods of measurements.

In this review, the linear measurements in use in ancient India, are examined and are compared with the corresponding measures, known to be in use in the corresponding period in other old civilizations in the world, with a view to compare the standards of measurements.

In ancient India, though the units were initially based on natural physical standards, they admitted by general consent many practical and imaginary dimensions also.

Moreover at different places, at the same time and at different periods in the same region, the units appeared to vary a great deal. The smallest unit of linear measure was

considered to be a *paramāṇu* (atom). Of the other measures, *trasareṇu, vālāgra, likṣa, yūkā* and *yava* each succeeding in eight times the previous one[10] (octonari system) are also known. Except *yava*, all the [illegible]asures seem to be of very minute analysis, probably [illegible] value for any practical purpose. Such impractical measures were reported elsewhere also and continued over a long period. For example the Babylonians started with the breadth of a line. Abul Fazl defines the digit in terms of barley corns and the barley corns in terms of the hair, from the mane of a Turkish horse.[11]

Aṅgula (finger-breadth or digit) can be considered as the smallest practical linear-measure in ancient India. This is the basic unit and all other linear-measure units depend on this. Hence this review is begun with the concepts relating to *aṅgula* (or the digit) and its equivalents in different systems. A definite standard measure can be considered from *aṅgula*, which is the length of the middle finger of an adult man having a height of at least six feet, *i.e.* a man of full height.[12] It had a length of approximately three-fourths of the modern inch (1.9 cms).

According to Śulva texts, an *aṅgula* is a unit of measurement equal to 14 grains of anu plant (*Panicum milliaceum*) or 34 sesame seeds[13], while according to Hindu[14] and Jaina literature[15], 64 sesame seeds or 8 *yava* (barley corn) constitute an *aṅgula*. Buddhist literature[16], however, refer to an *aṅgula* of 7 *yava* or 49 sesame seeds.

Based on these varying equations of length of an *aṅgula* with the size of grains and seeds, different systems have advocated varied equations, as discussed below.

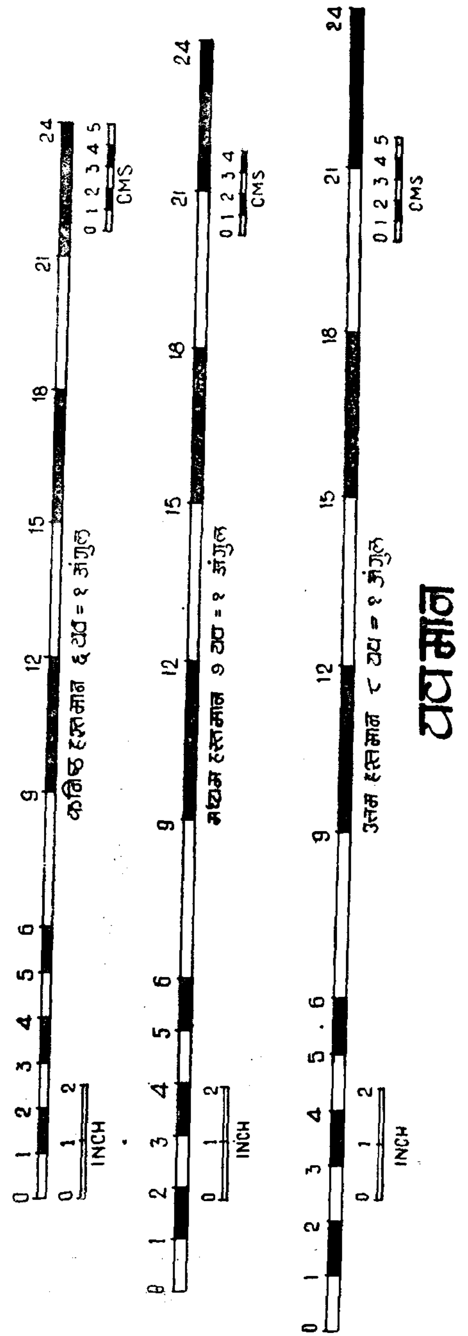
Jaina canons mention three types of *aṅgulas*; *utsedhāṅgula* or *sūcyāṅgula* (needle-like finger), *pratarāṅgula* (plane finger) and *ghanāṅgula* (solid finger), *i.e.*, the units of linear, area and solid measure respectively (linear, square and cubic measure). *Sūcyāṅgula* is linear and single dimensional. The product of *sūcyaṅgula* by itself, gives *pratarāṅgula* and this when again multiplied by *sūcyāṅgula* gives *ghanāṅgula*. *Tiloyopoṇṇatti*[15], refers to a *pramāṇāṅgula* which is equal to 500 *sūcyāṅgula* or *vyavahārāṅgula*. This seems to be a measuring rod, or such other device of about 500 *aṅgulas* long.

Mediaeval texts on architecture like Bhoja's *Samarāṅgaṇa-sūtradhāra*[17] and Bhuvanadeva's *Aparājitapṛchcha*[18] mention three other types of *aṅgulas*, namely *jyeṣtha* measuring 8 *yavas*, *madhyama* measuring 7 *yavas* and *kaniṣtha* measuring 6 *yavas*. *Jyeṣtha* was used in measuring cities, villages, lakes, etc., *madhyama* for measuring temples, palaces, houses, etc., and *kaniṣtha* for measuring furniture, carriages implements, etc. *Mātrāṅgula* referred to in *Viśwakarma Vāstuśāstram* and *Mayamatam*[19] was the length of the middle parva or mark of the middle finger or the thumb of the owner or sthapati. *Dehalabdāṅgula* is calculated on the basis of the statue of the principal deity.[19] In *Viśwakarma Vāstuśāstram*, 3 *vrihis* (paddy) are considered as an *aṅgula*[19]. Śukra considers 5 *yavas* as an *aṅgula*.[20] Sārangadeva[20], the celebrated writer of *Saṅgitaratnākara*, while describing the sticks (daṇḍa) on *Vīna*, refers to *aṅgulas* of 4½, 5, 5½, 7, 8 and 9 *yavōdaras*, indicating that breadth at the centre of *yava* was considered as a unit for measurements. According to him 6 *yavas* was the settled standard measure for an *aṅgula* in arithmetical calculations.[20]

As indicated so far, since, there were three types of *aṅgulas* equivalent to 6, 7 and 8 *yava* measures mentioned in vāstu-śāstras, efforts were made to find their equivalents in terms of modern inches and centimeters as shown in Chart I. 6 *yavas* were found to make 0.769 inches (1.9 cms); 7 *yavas* nearly 0.896 inches (2.22 cms) and 8 *yavas* nearly 1.024 inches (2.55 cms).

The inch (2.5 cms) was originally a thumb-breadth. In the Roman duodecimal system, it was defined 1/12 of a foot and was introduced as such into Britain during the Roman occupation. The finger-breadth or the digit among Egyptians (zebo) and Hebrews (ezba) was 0.74″ (1.87 cms) and among Greeks it was 0.8″ (1.9 cms). The Roman digit was 0.73″ (1.85 cms) and Uncia was 0.97″ (2.46 cms) which is closer to the present inch.[21] In the Arabic law book, *Ṣāra Vikāya*, it is stated that each finger breadth was equal to 6 barley corns, the bellies laid towards each other.[11] It can, therefore, be surmised, that the units, whether it was *aṅgula* or digit, measured somewhat between 0.7″ (1.78 cms) to 1″ (2.54 cms) in the ancient period and was considered as a standard linear

CHART - 1



Three Types of aṅgulas using Yava

measure.

The use of three types of *aṅgulas* in ancient India was confirmed by Abul Fazl also in *Ain-i-Akbari*. He mentions three types of linear measures of 8, 7 and 6 barley corns respectively. The longest one was for measuring lands, roads, etc., the middle for measuring temples, wells, etc., and the shortest for furniture, palanquin, etc.[11] Thus he seems to have followed the mediaeval texts of architects. Based on the *aṅgulas* many units of measurements were proposed in ancient India, as described below.

Dhanurgrha mentioned by Kauṭilya was a unit of four *aṅgulas*.[12] This measure seems to be similar to the four finger breadth or the palm of Greeks, which was 3″ (7.7 cms). The palm of Jews (tefah), Romans and Egyptians (shep) and Arabians (qabda) was 2.9″ (97.4 cms). This measure seems to be similar to that referred to as *muṣṭi* of four *aṅgulas* by Bhoja.[17]

Tala was a measure of five *aṅgula* according to Bhoja.[17] The distance between the top of the middle finger and the thumb when fully stretched was a *tala* according to Al-beruni.[22]

Dhanurmuṣṭi of Kauṭilya was of 8 *aṅgulas*.[12] Even in the 11th century, Bhoja refers to a measure *tūṇi*, which is also of 8 *angulas* and hence it is likely to be the same as *dhanurmuṣṭi*.

Pāda or *pada* is another important part of the body used for linear measure. A foot usually means the length of the sole, from the heel to the first digit of the toe. It is often confused with steps. In practice, it is seen that sometimes length was measured out both by sole length as well as by steps and hence it appears to be a variable unit in the past.

Baudhāyana mentions a *pāda* of 15 *aṅgulas* and a *kṣudra-pāda* of 10 *aṅgulas*. Kātyāyana refers to a *pāda* of 12 *aṅgulas*.[13] Kauṭilya refers to a *pāda* of 14 *aṅgulas*[12] which was accepted by Bhoja[11] also. *Śama*, *śala* and *pariraya* were the other names for *pāda* according to Kauṭilya. The term *śala* occurs in *Atharvaveda* also.[23] This term *pāda* is, however, unknown to Buddhist literature.

All these writers appear to use the term *pāda* synonymously with the foot.

When the land survey was undertaken by Kulottunga Cola I, his foot measurement was taken as a unit (*Śripāda*)[24]. This might be the Royal standard [illegible] Here, there is a doubt as to whether *Śripāda* represented [illegible] or the step. It is more likely to be a step, rather than the foot as in the case of the Roman concept of a mile.

Pāda also means a quarter. The four-footed animals are termed *catuṣpāda*. In poetry 1/4th part of a given verse is called a *pāda*.

In astrology also the stars and the houses are divided into four *pādas*. A quadrant of a circle is termed *pāda*. Hence this term *pāda* can also be interpreted as one-fourth of a bigger unit as seen in the Jaina literature[15] and Purāṇas.[14] They consider 6 *aṅgulas* as a *pāda*. This obviously is one-fourth of a *hasta* of 24 *aṅgulas*.

The term *pāda* appears to have been used for the square measure also. *Āvarta* means enclosed or surrounded. Hence *pādāvarta* mentioned in the Maitraka inscriptions[25] may be referring to an area or square land measured by so many *pādas* on adjascent sides. It may also refer to one-fourth of a bigger unit, perhaps a cubit or a *daṇḍa* or a *rajju* as the measure. In vāstu, *pāda* means a square of suitable size. Its dimensions are variable.

The foot of the Greeks, Romans and Jews was calculated from the basis of 16 times the digit. As the length of the digit varied, so the length of the foot also varied. The Greek foot was 12.16″ (30.9 cms); the Roman (Pes) 11.64″ (29.5 cms), the royal Egyptian 13.95″ (35 cms) and royal Babylonian 13.9″ (35 cms). The foot measure used in mediaeval England was 13.2″ (33.32 cms). The chih of China varies from 11″ (27.9 cms) to 15.8″ (40.2 cms).[21]

Till recently in certain areas in North Arcot district in South India, the length of the foot of the Goddess of the temple of Kampulapāliyam near Nārāyaṇavanam, which is approximately 10.25″ (26 cms), was taken into consideration as the standard measurement of the country foot[26] in that area.

These clearly indicate, that the foot (*pāda*) was one of the earliest linear units, probably starting first with the length of the average human foot and later the length of the specific foot. (King or headman or deity).

Gōkarṇa was another linear measure of 11 *aṅgulas* according to the *Samarāngaṇa sūtradhāra*.[17] Etymologically it means cow's ear and it is equated to the distance between the tip of the *anāmika* or ring finger and the thumb, both being stretched out according to Al-beruni.[22]

Vitasti or *Vidathi* (Pali) was known to Brahminical[14], Jaina[15] and Buddhist[16] literature. It is the distance between the tip of the thumb and the small finger at the widest possible stretching or in other words the span. It also depicts the distance from the wrist to the tip of the middle finger, when stretched. It is 13 *aṅgulas* according to Śulva texts[13] and 12 *aṅgulas* according to Kauṭilya[12], Jaina[15] and Buddhist[16] texts.

Pāṇini mentions a *diṣṭi* also along with *vitasti*.[27] The word *dithi* occurs in Karoṣṭi manuscripts from Central Asia, corresponding to the Iranian distay, equivalent to a span.[28] In the *Samarāngaṇa sūtradhāra*, a *vitasti* was of 12 *aṅgulas* and *diṣṭi* was of 7 *aṅgulas*.[17] The span of ancient Jews (Zeret) was 8.8″ (22.5 cms), the Greeks 9.1″ (23.1 cms) and the Assyrians 10.8″ (27.4 cms). *Vitsati* as used in Persia was 10.7″ (27.2 cms). The scales of Gudea maintain a 10.44″ (26.4 cms) measure.[7]

Prādeśa is another span measure which according to Śulva sūtras[14] was of 12 *aṅgulas*, while according to Bhoja[17] it was 9 *aṅgulas*.

Hasta, the popular hand measure, is the cubit of 24 *aṅgulas*. It is in colloquial use even today as 'hāth' in North India and '*muḷam*' in Dravidian speaking areas. The Śulva sūtras[13], Purāṇas[14], Jaina literature[15], *Arthaśāstra*[12], treatises on architecture like *Mayamatam*[19] and *Samarāngaṇa sūtradhāra*[17] refer to a *hasta* of 24 *aṅgulas* (192 *yavas*). In *Lalitavistāra*[16] also a *hasta* constituted 24 *aṅgulas*. It may be noted here, that since 7 *yavas* were equal to an *aṅgula* in *Lalitavistāra*, *hasta* was of 168 *yavas* according to that work.

Architectural works, in addition to the *hasta* of 24 *aṅgulas* refer to three other types of *hastas* also. For measuring *vimāna* a *hasta* of 25 *aṅgulas*. termed. as *prājāpatya hasta*, and for building (vāstu), a *dhanurmuṣṭi hasta* of 26 *aṅgulas* were used. For measuring villages, *dhanurgṛha hasta* of 27 *aṅgulas* was advised. It is interesting to note that till recently the timber

in the forests was measured with bigger cubit, which is a cubit plus four *aṅgulas*. All the same 24 *aṅgula-hasta* could have been used for these things also.

It seems that these variati[illegible]ht have been helpful in measuring objects of widely differ[illegible]ths. Longer units would help in measuring larger area in fewer repetitions, while the smaller measures would help where more accuracy was needed.

Kauṭilya's *prājāpatya hasta* or *aratni* was of 24 *aṅgulas*. For measuring balances, cubic measures and pasture lands, a *hasta* of 28 *aṅgulas* was prescribed by Kauṭilya. A *hasta* measuring 54 *aṅgulas* for measuring timber forests was also advised by Kauṭilya.

If Kauṭilya's *aṅgula* is considered as three-fourths of an inch, 24, 28 and 54 *aṅgulas* will be equal to the modern 18″, 21″ and 40.5″ (45.7, 53.34 and 102.87 cms). Concepts relating to *hasta* had changed during different periods, as could be seen from Junagadh inscriptions. In the Junagadh inscription of Rudradāman issued in the year 72 (151 B.C.—52 A.D.), the repairs to the breach made in the Sudarśana lake was recorded in terms of *hastas*. As indicated in *Aparājitapṛchcha*, for larger measurements referred to in Rudradāman's inscription, the unit of *hasta* was equal to eight *aṅgulas*[29] and when Skandagupta repaired the tank, the unit of *hasta* indicated by him was almost treble to that of Rudradāman.[30]

Different types of cubits were in vogue in other places also. Ezekiel (600 B.C.), who wrote in Babylon, mentioned that the courts and open spaces around the temple were measured, by a reed of 6 cubits, each of which was a palm breadth longer than the cubits of the measuring line.[9]

In some inscriptions, it is definitely stated that the *hasta* of the king was used for measuring land. In the *Vāillabhaṭṭa-swāmin* temple inscription[31], a piece of land was measured on the basis of the *hasta* of the king (*Parameśwarīya hasta*). The land referred to in this inscription covered a flower garden measuring 270 *hastas* in length and 187 *hastas* in breadth. *Śivacandra hasta* refers to the forearm of King Sivacandra[32] and the term *Darvīkarma hasta* (the forearm of Darvīkarma) occurs in the inscriptions from Bengal.[32]

The cubit of 24 fingers, which is the old Arabic cubit, was variously called the common, post, hand, or legal cubit (*dhira,*

amma, barid, yad and *shari*)[10]. The cubit relating to the pyramids however was 20.6″ (51.6 cms).

The Jewish civil cubit of five palms or 20 finger-breadth was 18.25″ (46.25 cms). The Jewish sacred cubit of six palms, the Royal Babylonian, the Arabian, the Russian and the Chinese cubit of 24 fingers were 19.5″ (49.7 cms), while the Nilometer cubit measured 20.76″ (52.5 cms) and the Roman cubit was 17.4″ (44.1 cms). The Arabian royal cubit (*dhira malik*) of 28 fingers or 7 palm breadth was also known and it measured 21.22″ to 21.26″ (53.85 to 53.89 cms).[21]

According to *Ṣāra Vikāya*, an Arabic law book, the *Zira* was of 24 fingers and each finger measured 6 barley corns.[11]

Aratni which is equal to 24 *aṅgulas* appear to be synonymous with *hasta* and cubit, since it is also the portion of the hand from the elbow to the tip of the middle finger. This length of 24 *aṅgulas* is accepted by *Śulva sūtras*[13], *Arthaśāstra*[12] *Bṛhatsaṁhita*[34], Buddhist[16] and Jaina literature[15]. Utpala, however, takes it to be a smaller cubit with the fist-closed.[34] 21 *aṅgulas* were considered as *ratni* and 24 *aṅgulas* as *aratni* in the *Samarāṅgaṇa sūtradhāra*.[17] Thus majority of the literature confirm the fact of *aratni* to be a cubit. It may be noted here that *arasni* in Persia was 21.4″ (54.35 cms).

The present day cubit is one-half of the British yard and hence an ordinary *hasta* or *aratni* of 24 *aṅgulas* can be safely ascertained as half a yard.

Gaz was also a type of measuring standard. Abul Fazl records seven types of *gaz*. *Gaz-i-sauda* (*Gaz* of traffic) consisted of 24 digits plus 2/3 of a digit. This measure, according to him was the length of the hand of an Abyssinian slave of Harun-Al-Rashid and was equal to the cubit of the Nilometer. He also has referred to different types of *gaz*, having 24, 25, 28, 29, 31 and 70 *digits*. The last one was used for measuring rivers and plains.[11] During the time of Moghuls, several types of *gaz* were in vogue. Sikandar Lodi's *gaz* was 39 *digits* or 41½ Sikandaris (30.09″, 72.2 cms). Humayun's gaz was 39 *angusts* or digits, Akbar's *Ilahi gaz* was 41 *digits* (31.00″ or 81.3 cms) and Shah Jehan's 40 *digits*.[35] The *Ilahi gaz* at Agra during 17th century A.D., was 33″ (83.8 cms). In the east coast during 17th century A.D., the *hasta* or *covad* was

about 18″ (45.7 cms) and in Gujarat 27″ (68.5 cms) according to the Portuguese records.[36]

Prakrama of the *Baudhāyana Śulvasūtra* and the *Śatapatha Brāhmaṇa* was equal to two *pād*[illegible]*gulas*) and might be even 3 *pādas* according to Āpst[illegible]. *Prakrama* literally means a stride and is very rare in literature and epigraphical records. It may be noted here that the Roman step was 29″ (73.6 cms) and the Greek 30.4″ (77.2 cms).

Jānu, which literally means knee, is mentioned in *Śulva sūtras* as a measure of 32 *aṅgulas*.[32]

Daṇḍa, which literally means a rod, was considered to be of 4 *hastas* or 96 *aṅgulas*. *Dhanus*, *musala*, *nālika* and *akṣa* were its other names according to Jaina literature.[15] Kauṭilya mentions three types of *daṇḍas*, first measuring 96 *aṅgulas*, the second measuring 108 *aṅgulas* used by builders for measuring roads and fort walls and a third *daṇḍa* of 192 *aṅgulas* used in measuring such lands which are gifted to Brāhmanas.[12]

Jaina[15] and Buddhist literature[16] stick to 96 *aṅgulas* as a *daṇḍa*. Varāhamihira was on safer side in mentioning a *dhanus* as of 4 hastas and a *daṇḍa* between 4 to 5 *hastas*.[34] Though *daṇḍa* was not mentioned in the *Abhidhānappadīpika*, *yasti* of 84 *aṅgulas* was mentioned, which might be closer to a *daṇḍa*.[16] *Akṣa* having 104 *aṅgulas* mentioned by Patañjali[37] and *Śulva sūtra*[13] may also be a measurement rod.

Yuga of the *Śulva sūtra* was 86 *aṅgulas* and *vyāyāma* 96 *aṅgulas*[13] *Samarāngaṇa sūtradhāra* refer to a *daṇḍa* of 106 *aṅgulas*[17] also.

The Kannaḍa *gale*, Telugu *kola* and Tamil *kol* are the counterparts for *daṇḍa* in the respective regions.

Bheruṇḍa gale[28], *Parvāra gale*[39], *Ovantaramalla gale*,[40] *Benkalva gale* (13 span)[41], *Bhūguḍa gāle* (18 span), *Tambla gale* (rod of Tamil country)[42], *Dhānavinoda gale* (25 span)[44] and *Agradimba gale*[45] were the various measuring rods, stated in the Kannaḍa inscriptions. *Śrīpādakkol* (the rod of the king's foot with reference to Kulottunga I)[46] and *Maḷigaikkol* (the rod of the palace)[47] and *kaḍigaikuḷattukkol*[48] were mentioned in the Coḷa records. The varying length of the rods is given in the records as 4, 12, 13, 16 or 18 spans, 36 or 48 steps and 12, 14, 16 or 20 feet. There are also references to

measuring rods 24, 32 or 34 feet long.

Different types of *kolas* of varying length were also found in Telugu inscriptions. They are *reṇḍu jeṇala kola* (2 spans)[50] 20 *jeṇala kola* (20 spans)[51], 22 *jeṇala kola* (22 spans)[52], *muppai reṇḍu jeṇala kola* (32 spans)[53] (muppai means 30 and jena or span is about 7 inches). Adugu in Telugu means foot and hence the term 30 *adugula kola* may mean the pole having 30 foot length. *Mura* is a Telugu measure corresponding to a cubit.

In the Kannaḍa records, the terms *Paṭṭyamattavūra daṇḍa* (the measuring rod of the village of Paṭṭyamattavūra)[56] and *Eḍenāḍa daṇḍa* (the measuring rod of Eḍenāḍa country)[57] also occur showing the regional variations.

Sometimes the gift of lands is reported to have been measured with *Rājamānadaṇḍa*, which might be the royal standard or the length of the rod assigned by the Government concerned. *Rāja daṇḍa* of *Viśvakarma Vāstuśāstram* was double the size of ordinary *daṇḍa* of 96 *aṅgulas*.[19]

Though the *daṇḍa* is a linear measure, when used in the epigraphical records, it might perhaps also mean square *daṇḍas*, that is, a number of *daṇḍas* each way.

The pole of the ancient Greeks was of 100 fingers measuring 6.3′ (1.93 metres) and their fathom of 96 fingers measured 6.1′ (1.85 metres). The Roman pole was 9.7′ (2.957 metres). The *daṇḍa* of ancient India also varied from 6′ to 10′ (1.83 to 3.04 metres). Moreover the *daṇḍa* in the inscriptions refer to the measuring rod of varying lengths at different periods. But the mathematical works generally agree to 96 *aṅgulas* for a *daṇḍa* which falls between 6′ to 8′ (1.83 to 2.44 metres) varying with *aṅgulas* measure.

Abul Fazl equates the pole (*bea*) of the Arabs to four *gaz* (96 digits) which is the same as the Indian *daṇḍa*.[11]

Vamśa mentioned by Vasiṣṭha[59] and Bhāskarācārya[60] was of 10 *hastas* or 240 *aṅgulas*. The term *vamśa* literally stands for bamboo. According to the Gujarati commentary on Śridhara's *Pāṭigaṇita*, *vamśa* was equal to 3 *daṇḍas* or 312 *aṅgulas*.[61]

Kiṣku or *kamsa* was two *vitastis* plus one *dhanurmuṣṭi* or 32 *aṅgulas* according to Kauṭilya.[12] It was a measure employed

for measuring forts and palaces. Kauṭilya mentions a *kiṣku* of 42 *aṅgulas* also, for measuring the ground for the encampment of the army, forts and pa[illegible] Mahāvīra also mentions a *kiṣku* of 42 *aṅgulas* for meas[illegible]ood.[61]

The term *kiṣku* is used in Araṇyakaparva of *Mahābhārata*.[62] *Kiṣku, rikku* and *kuchchi* of Jaina literature are of 48 *aṅgulas*.[15] According to Purāṇas[14] and the *Samarāṅgāṇa sūtradhāra*[17], it is a measure of 42 *aṅgulas*. Childers equates *kikku* of the Buddhist literature with *hasta*, but phonetically it could be identified with *kiṣku*. *Kiṣku* and *vitasti* are synonymous according to Al-beruni.[22]

Bāhu apparently meaning an arm, was 36 *aṅgulas* according to Baudhāyana.[13] Kauṭilya's *bāhu* did not seem to have any connection with this, since he specified *bāhu* as the distance of 3 *rajjus* plus 2 *daṇḍas* on each side (128 daṇḍas in circumference).[12] *Bāhu* was also termed as a *śamya* according to Baudhāyana and *śamya* of Āpastambha also measures 36 *aṅgulas*.[13] According to *Mayamatam, ratni, aratni, hasta, bhuja* and *bāhu* are synonymous.[19]

Yaṣṭi or *yatthi* (Pāli) occurs in the sense of a staff in Buddhist literature measuring 7 *ratanas* or 84 *aṅgulas*.[16] In the *Śatapatha Brāhmaṇa* the term *veṇu yaṣṭi* occurs, meaning a bamboo staff.[14] *Yaṣṭi* or *dhanurdaṇḍa* is of 96 *aṅgulas* according to *Mayamatam*.[19] Till recently ***yaṣṭi*** is 28×28 sq. cubits or 1/336 of a *hala* in Sylhet.[63] This indicates that on linear scale *yaṣṭi* might be equated to 28 cubits. It has also been suggested that a *yaṣṭi* might be 2 *vitastis*. *Yaṣṭi* occurs only in the Sena land grants.[64]

Usabha which frequently occurs in Jātakas was considered as 20 *yaṣṭi* or 1/8th of a *goruta*.[65]

Vyāma according to *Śulvasūtra*[13] and the *Śatapatha Brāhmaṇa*[14] was 120 *aṅgulas*. It is the height of a *puruṣa*, with his arms stretched up. According to Kautilya a *vyāma*, was 84 *aṅgulas* and used for measuring ropes and for digging.[13] Aśvalāyana prescribes *vyāma* for measuring the dimension of a ground, where a deceased person is to be cremated.[66] *Vyāma* was stated as 84 *aṅgulas* by Bhoja.[17]

Vyāyāma was 96 *aṅgulas*, according to Baudhāyana.[13] It was the space between the two tips of the middle fingers of a

man with outstretched hands, while standing. The term *vāma* in Gujarati stands for the measure *vyāyāma*. In Thailand it is termed as *va*.[67]

The distance, known as *mār*, in Tamil speaking areas and *baralu* in Telugu are of 72″ (1.8 metres). These relate to the extent of tip to tip of the extended hands of a man. An inscription from Candaluru, refers to a gift of land measured with a pole of 12 *baralu*.[68] If Baudhāyana's *aṅgula* was taken as 3/4″ inch, then *vyāyāma* would be synonymous with *mār* and *baralu*.

Yuga measuring 86 *aṅgulas* occurs in Śulva texts[13]. According to Jaina literature[15] and Bhoja[17], *yuga* is synonymous with a *daṇḍa* of 96 *aṅgulas*. Probably it is four times the limits of a measure, perhaps *hasta*, if Nighantu is considered.

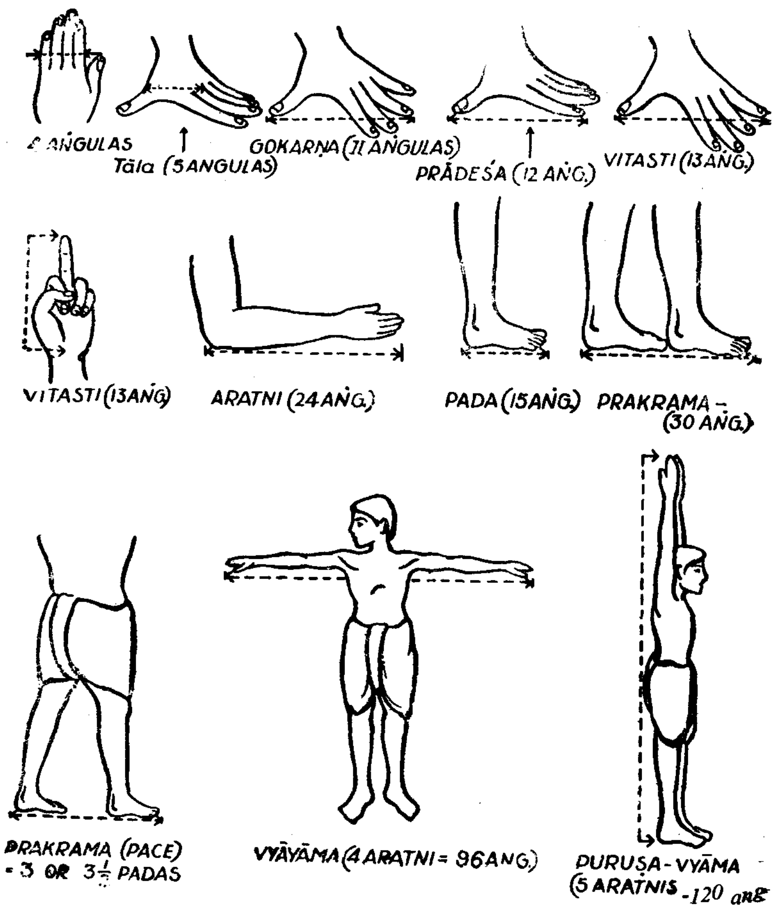
Iṣā measuring 88 *aṅgulas* is another linear measure occurring in Śulva texts only.[13]

Akṣa is the other name for *daṇḍa* of 96 *aṅgulas* according to Jaina literature.[15] But the Śulva texts mention an *akṣa* of 104 *aṅgulas*.[13] Patañjali also refers to this measure.[37]

Puruṣa or man's length was 120 *aṅgulas* according to Baudhāyana and Āpastamba.[13] They probably use the term *puruṣa* as synonymous with *vyāyāma*. Kauṭilya mentions a *puruṣa* measure of 107 *aṅgulas*, which was used in building sacrificial altars and also mentions another *puruṣa* measure, equal to a *daṇḍa* of 96 *aṅgulas*.[12] According to Varāhamihira, a normal man measures 96 *aṅgulas* (4 *hastas*), low man measures 84 *aṅgulas* ($3\frac{1}{2}$ *hastas*) and finest man 108 *aṅgulas*[34] ($4\frac{1}{2}$ *hastas*). This seem to refer to a standardized unit and not that of the individual. According to Bhoja also *vyāma* of 84 *aṅgulas* was synonymous with *puruṣa*.[17] Thus the measures *puruṣa* and *vyāma* appear to have been used loosely, both to mean a particular unit by some, while others used it for the heights of a man with hands stretched up, approximately measuring between 1.5 metres to 2 metres. The longest measure mentioned in the Śulva texts and Brāhmaṇa literature was *puruṣa*. Since the main aim in these literatures was building fire altars, the measurement bigger than a *puruṣa* was probably not necessary.

PLATE I

Linear Measures in Ancient India in Relation to the Parts of the Body



All these above measurements are in relation to the parts of the human body (see plate 1).

Nālika, nala, nalu, nali, nādi, nāluka and *nalva* are terms regarding other linear measures, occurring in inscriptions and in literature.

In the Jaina literature[15] and the *Arthaśāstra*[12] the *nālika* stands for a *daṇḍa* of 96 *aṅgulas*. In the *Ādityapūrāṇa*[59], 30 *dhanus* of 96 *aṅgulas* was a *nalva*. *Nāli* was equal to *dhanus*. In the *Mārkaṇḍeyapurāṇa*,[14] the term *nādika* measures 48 *aṅgulas*. *Nādi* measures 96 *aṅgulas* and *nalva* measures 30 *dhanus* of 106 *aṅgulas* in *Samarāngaṇa sūtradhāra*.[17] Al-beruni has stated 40 *dhanus* of 96 *aṅgulas* as *nalva* which was 1/25th of a *krośa*.[22] *Nala* appears in *Pañcatantra*[69] and in *Bhāgavata* in the sense of a reed.[70] Thus, *nāli, nālika* and *nādi* can be said to measure 96 *aṅgulas* while *nādika* 48 *aṅgulas* and *nalva* 40 or 30 *daṇḍas*.

Generally, *nala* in Sanskrit means a measure, rod or *daṇḍa*. The length varies in different places according to local customs and usages. In the Sankareh tablets, six types of reeds viz. small, medium, large, double small, double medium and double large reed measures were used in Babylon.[7] The ancient Greek measure *Xylon*, meaning a walking staff was of 3 cubits or 4.6 ft. (1.39 meters).

The term *nala* is used in the records of Guptas, Pālas and Senas in the sense of *daṇḍa*. This term mostly occurs, in the inscriptions in the Eastern India, and rarely in Western and Northern India and is absent in South. During the time of Guptas, it looks as if the actual measurements were done by *nalas* mainly. In some of the copper plates, the *nala* is qualified by the figure 8 and 9 (*aṣṭaka navaka nalābhyam; aṣṭaka navaka nalena*). In the Pahārpur copper plates dated Gupta year 159 (479 A.D.) the *nala* was qualified by the figure 6×6 (*ṣaṭka nalairapavincya*).[71] However, from the copper plates of the time of Kumāragupta (5th century A.D.)[72] to those of the time of Vijayasena (the Barrackpur copper plates—12th century A.D.) the *nala* measuring 8×9 was the common measure.[33] *Nalas* were also associated with the names of certain persons or plates. The term *Vṛṣabha Śaṅkara nala* occurs in the Naihāti copper plate of Vallālasena (12th century A.D.)[73] and

Ānuliā plate[74] and Saktipur plate[75] of Lakṣmaṇasena (12th century A.D.) Vṛṣabha Saṅkara was the biruda of Vijayasena. *Samatāṭīya nala*, was evidently the measuring standard used in the Samatāṭa country or South East Bengal and also in the Khaḍi viṣaya of P... ...dhana-bhukti (North Bengal).[32] A *nala* current in Varendri (*tatraya deśīya samvyavahāra nalena*) occurs in Tarpandigi plate of Lakṣmaṇasena.[76]

In the Govindapur copper plate of Lakṣmaṇasena measurement of 56 cubits, prevalent in that region was mentioned (*ṣatpañcāśata hasta parimita nalena*).[77] In the Sunderban copper plate of Lakṣmaṇasena, a standard of 22 cubits (*dwātrimśatihastena parimita*) was used.[78] These show, that local standards differed from place to place.

Moreover, the *nalas* appear to have been measured in different *hastas*. The *hasta* of Śivacandra was used in the Faridpur copper plate of Dharmāditya (during Gopacandra's regnal year 18).[32] In the Baigrām copper plate (448 A.D.) and in the Barrackpur grant of Vijayasena, the term *Darvīkarma hasta* measuring 8×9 *nalas* occur.[33] Darvīkarma may perhaps be a personal name or a common term for an employee in charge of demarcation. In the Kāhla (Lucknow museum) plates of Kalachuri king Mahārājādhirāja Soḍhadeva, successor of Mahārājādhirāja Maryādasāgaradeva (V.S. 1135), several land grants were made in terms of the measure *nalu*.[79] Since a land measuring 3/4 *nalu* was also given as a grant, it must be a fairly big unit representing a large area.

In two records of Govindacandra and his mother Rālhanadevi (1189 A.D.) from Pāli, the term *nāluka* occurs. The former records 10 *nālukas* and the latter 20 *nālukas*.[80]

Chebrolu inscription of Jaya (S.S. 1157) refers to 6 *na* which is translated by Kielhorn as *nālvamu* or furlong.[81]

In the Gagaha plate of Govindacandra (V.S. 1199) of Kanauj, Mahārājaputra Rājyapāladeva gifted certain lands measuring in *nālu and pañca*.[82]

Till recently in Sylhet, *nala* refers to a linear measure of 7 cubits. *Nālva* is considered as of 100, 120 or 400 cubits by different authors. The *Vaijayanti* refers to a *nālika, nālvika*, and *nāla* measuring 5½, 8, 9 or 400 hastas.[83]

Rajju which literally means a rope, was used for land

surveying. Rajjuka and Rajjugakaha-amachcha were the land surveyors according to the Jātakas and inscriptions of Aśoka and those of Śātavāhanas. In the Prakrit Sānchi Stūpa inscription (no. 230) the donor was Rajjuka Uttara.[85] In the Maḷavalli Pillar inscription of the Raja Hariputra Viṣṇu-kada Cutukulānanda Śātakarṇi, an order concerning a gift of land to an officer Rajjuka Mahattara is mentioned.[86]

Rajju of Kauṭilya was of 10 *daṇḍas*, while that of Śrīpati[87] was of 20 *daṇḍas*. If Kautilya's *daṇḍa* of 196 *aṅgulas* is taken into account, then both will indicate the same measure. According to *Mayamatam*, it was 8 *daṇḍas* of 192 *aṅgulas*.[19] The word *pāśa*, occuring in the Royal Asiatic Society's copper plate grant of Bhima II of Gujarat may be synonymous with *rajju*.[88] A feudatory Mahipala was said to have given 340 *pāśas* in a village Bhukarada, producing four *khaṇḍas* of grain.

Measuring by hempen rope was mentioned by Abul Fazl. Ancient Greeks measured the distance by a cable of 60 Greek feet (61 British feet or 18.5 metres). Just like the inch tape or centimetre tape or the modern measuring chains, measuring by a particular rope, must have been common in many areas. Measuring by rope is convenient, when the sides of a particular land is not in straight lines, as in the case of ponds.

In the Tamiḻ speaking areas, the rope measuring 32 yds (29.25 meters) was in vogue till recently. The British chain, better known as Gunder's chain, is 66 ft or 1/10th of a furlong (26.11 metres). Ten sq. chain is an acre.

Krośa and Gavyūti: Unlike the previous measures, these represent long distances. The word *krośa* literally means a cry, shriek or yell. The word *gavyūti* or *goruta* (Gauta—Pāli) applies to the distance upto which the bellowing of the cow can be heard. *Kiosses* in Siberia also has the same meaning. The distance, represented by *kiosses* however, varies from place to place.[89] The Tamiḻ word *kūppiḍudooram*, refers to the distance from which a shout can be heard. *Krośa* and *goruta*, occur mainly in literature and hardly in inscriptions. There seems to be different types of *krośas*. Kauṭilya mentions a *krośa* equal to 100 *dhanuṣ* or 1/4 of a *yojana*.[12] *Magadha*

krośa mentioned by Bhoja was 1/8 of a *yojana* or 1000 *daṇḍas*.[17] Śukra quoting from Manu refers to a *krośa* of 4000 *hasta* or 1000 *daṇḍas*[20a]. On the other hand in the *Mārkaṇḍeyapurāṇa*[14], Jaina literature[15] and in the mathematical works of Bhāskara[60], Mahā[illegible]d Śridhara[61], references to a *krośa* of 2000 *daṇḍas* are given.

In Aśoka's 7th pillar edict, it is stated that he laid out camping grounds, provided with wells and rest houses, along the high roads at intervals of $\frac{1}{2}$ *krośas*[91].

A peep into Strabo's account, vaguely helps to deduce the distance represented by a *krośa*. "They (i.e. Agromoni) construct roads and set up a pillar at every 10 stadia."[92] Greek and Roman stade was 604 ft (185 meters) and the stadion of Hebrews 558 ft (160 meters). Anyone of these multiplied by 10 might be the *Magadha krośa*, which is closer to the modern mile.

Śukra refers to a *krośa* of 500 *daṇḍas* quoting from Prajāpati. A *krośa* of 250 *daṇḍas* is also mentioned by him. The Villages were measured by a *krośa* of 500 *daṇḍas* according to the *Mayamatam*. Dr R.N. Mehta comes to the conclusion from his excavations at Vadanagar that a *krośa* is approximately a kilometre. Perhaps the *hasta* of 8 *aṅgulas* as indicated in the *Aparājitapṛchcha* or the *aṅgulas* equalling to 3 *vrihis* as mentioned in the *Viswakarma Vāstuśāstram* might have been taken into account.

Al-beruni also compared *krośa* to a mile.[22] According to Abul Fazl the *kos* or *kuroh* of Gujarat was 50 jaribs and it was the greatest distance, at which the bellowing of the cows can be heard. Some of his statements, however, are not corroborated by any other writer.

The Moghul kings established a different *kuroh* or *kos*. Sherkhan fixed the *kos* at 60 *jaribs*. Each *jaribs* contained 60 *Sikandari gaz*. Each *Sikandari gaz* was equal to $41\frac{1}{2}$ *Sikandaris*, which was equal to 30″ (76.2 cms). Therefore, the *kos* comes to 1.7 miles (2.75 km) according to modern calculations. Akbar recognised a *kos* of 5000 *Ilahi gaz* with the value of one *Ilahi gaz* being 41 *digit*. Jehangir ordered Serais to be built at every 8 *kos* between Lahore and Agra. The distances between these Serais varied from 9 to 13 miles. According to this, *Kos* in the period of Jehangir, varied from 1.1 mile (1.77 km) to 1.7 miles (2.75 km)[94]. Shah Jehan fixed the kos as 5000 *Zira-i-padshahi*, each Zira measuring 42 *aṅgulas*.

Some writers have stated that 2000 or 1000 *dhanus* make one *gavyūti* or *goruta*. This tends to suggest that *gavyūti* and *krośa* are synonymous. But in *Mārkaṇḍeyapurāṇa* 4 *krośas* are considered to be a *gavyūti* and 8 *krośas* as a *yojana*.[15]

Hieun Tsang describes a *yojana* as equal to 8 *krośas* of 500 *dhanus*.[95] But generally either 4 *krośa* or 4 *gavyūti* is considered as a *yojana*.

An old Turkish verse equates *kos* or *kuroh* with *mil* which was 400 paces (a pace=324 *yavas*.

Dr Cunningham[94], adopting the value of *hasta* as 25 *aṅgulas* has come to the following conclusion:

4 *hastas* or 100 *aṅgulas*=6.052′=1 *dhanus*
400 *hastas* or 100 *dhanus* =605.2′=1 *nalva*
4000 *hastas*=100 *nalva* =6052′ =1 *krośa*

This is closer to the 10 stadias mentioned by Megasthenes. The *kos* of Gangetic provinces, appears to be about $2\frac{1}{2}$ miles (3.35 km) in length, while in Punjab it is $1\frac{1}{4}$ miles (2.25 km) and in Bundelkhand and Mysore it is 4 miles (6.44 km). The Tamil *kādam* is equated with *gavyūti* in the lexicons. However, it is doubtful, since a *kādam* is generally considered to be equal to 10 miles (16.09 km).

Yojana is the most controversial linear measure, with the least unanimity among the scholars. It has been referred to in *Rāmāyaṇa*[95], stating the distance of the sea, which Hanumān crossed to be of 100 *yojanas*. The ancient Tamil work *Maṇimekalai* refers to a distance of 400 *yojanas*.[97] These indicate *yojana* as a big stretch of length representing several miles.

There appears to be two different types of *yojana* according to the ancient Indian literature. One of 4000 *daṇḍas* and the other of 8000 *daṇḍas*. According to the *Arthaśāstra*[12], the *Lalitavistāra*[16], the *Gaṇitasāra* of Śrīdhara[61] and the *Aparājitapṛchcha*[18], 4000 *dhanus* were equal to a *yojana*, whereas *Brahmagupta*[98], *Āryabhaṭa*[99], Jaina canonical literature[15], Mahāvīracārya[90], Bhāskara[60] and Śrīpati[87] assert, that a *yojana* is equal to 8000 *dhanus*. The *Vaijayanti* refers to a

Kosala yojana of 4 *gavyūti* and *Magadha yojana* which is half the size of the former.[83]

According to Kauṭilya[12], a *yojana* was of 4000 *dhanus*. If, however, Bhaṭṭaswāmin's interpretation of it is considered, it must be exactly double of that. [illegible] the controversy arises as to which type of *dhanus*, Kau[illegible] [illegible]as taken into account. Kauṭilya has mentioned a general *dhanus* of 96 *aṅgulas*, *gārhapatya dhanus* of 108 *aṅgulas* and *Brahmadeya dhanus* of 192 *aṅgulas*. If *aṅgula* is considered as an inch (8 *yava* was an *aṅgula* according to Kauṭilya) then the different *yojanas* would be 6.06 (9 km), 6.63 (10.62 km) and 12.12 (19.5 km) miles. If *aṅgula* is considered as $\frac{3}{4}''$, then these would be 4.54 (7.3 km), 5.1 (8.2 km) and 9.09 (14.5 km) miles. Since *yojana* generally refers to a distance and not length of lands, the general *dhanus* is more relevant. Jaina canons[15], Purāṇas[14], Mahāvīrācarya[90], Śrīdhara[61] and Bhāskara[60], refer to *yojana* of 8000 *dhanus* (768,000 aṅgulas). And hence, it would be 12.21 miles (19.5 km) if the *aṅgula* was considered as an inch and 9.09 miles (14.5 km) if the *aṅgula* was considered as $\frac{3}{4}''$.

Kannaḍa writer Rājāditya, in his *Vyavahāragaṇita* considered 800 *daṇḍas* (76800 *aṅgulas*) as a *yojana* and hence it might be 1.21 miles (1.93 km) or 0.9 miles (1.09 km).[101]

According to Bhuvanadeva, though 8000 *daṇḍas* is a *yojana*, a *daṇḍa* measured only 32 *aṅgulas*.[18] Hence the *yojana* according to him would be approximately 3 miles (4.83 km).[29]

In stating the distances of one place from another, the Chinese travellers Fa-Hien and Hieun Tsang have expressed them in *yojanas*. The latter has also stated them in *li* measures. Fa-Hien has stated the distances in *yojanas* in full numbers and never in fractions, while Hieun-Tsang expressed them in round figures of 10, as 500 *li* or 600 *li*. Moreover, the distances mentioned by them from one place to another failed to indicate, whether it was from periphery to periphery or from the official centre, as in the present day.[101]

Hieun Tsang has mentioned that a *yojana* is a day's march for a royal army; there were three types of *yojanas*; one of 16 *li* found in the sacred writings of Buddha, 30 *li* which was common reckoning in India and 40 *li* according to the old

Chinese records. 8000 *daṇḍas* comprise a *yojana* according to him.[101]

The army's march, as stated by Kauṭilya, differ from Hieun-Tsang's description. The lowest quality army, according to Kauṭilya, can march a *yojana* [5-5/44 miles (8.2 km) according to Shamasastry] a day, that of the middle quality one and a half *yojana* and the best quality two *yojanas*.[102]

The *nāḷigai vaḷi*, i.e. the distance covered in a *nāḷigai* (24 minutes), is $1\frac{1}{3}$ miles (2.59 km) in Southern districts. This is roughly the distance covered by infantry in present time. If the army moves for eight hours, taking this *nāḷigai vaḷi* as the standard ($\frac{64}{24} \times \frac{4}{3} \times 8$), the distance covered in a day will be $26\frac{1}{3}$ miles (42.91 km). Hence, the *yojana* mentioned by Kauṭilya might be between 12 to 13 miles (19.31 to 20.92 km).

From one of the accounts of Hieun Tsang it is clear that a *yojana* is equal to 16 *li*. The account is as follows. When on a visit to Rājagṛha, Anāthapiṇḍika, a merchant of Śrāvasti, became a Buddhist and invited Buddha to visit Śrāvasti. The distance from Rājagṛha to Śrāvasti was forty-five *yojanas*. Buddha set out to reach the city by sixteen *li* a day and he took forty-five days in travelling from Rājagṛha to Śrāvasti.[103]

Many scholars give different values to the *yojana* of the Chinese traveller. General Cunningham has asserted the *yojana* of Hieun Tsang to be as 6.75 miles (10.86 km) and that of Fa-Hien as 6.71 miles (10.79 km). V.A. Smith considered a *yojana* of Hieun Tsang as 6.5 miles (10.5 km) and of Fa-Hien as 7.25 miles (11.67 km). M. Julien and probably Dr Stein referred the *yojana* of Hieun Tsang as 8 miles (12.87 km) and M. Giles was of the opinion that a *yojana* of Fa-Hien was between 5 (8.05 km) to 9 miles (14.48 km) while Rhys Davids took its distance as about 9 miles (14.48 km) and Childers $4\frac{1}{2}$ (7.29 km) to 9 miles (14.48 km).[151]

Fleet considered that there were three types of *yojanas*; general *yojana* of 9.09 miles (14.58 km), Magadha *yojana* of 4.54 miles (7.3 km) and the third *yojana* of 12.12 miles (19.5 km). The last one, he interpreted from the root 'yuj' to yoke and hence it is said to represent the distance which a pair of bullocks could draw a fully laden cart in a day. According

to his interpretation 12.12 miles (19.5 km) were equal to 100 *li* of Hieun Tsang. Major Vost, after a detailed analysis, interpreted the three *yojanas* of Fleet as 5.3 (9.03 km), 10.6 (17.85 km) and 14.2 (22.85 km) miles respectively. He deduced the *yojana* of Fa-Hien and Hieun Tsang as 7.05 (11.3 km and 5.3 (9.03 km) miles respectively.[95]

Several modern scholars have tried to infer the distance measured by the *yojana*, from astronomical facts provided by our early writers. In the *Āryabhaṭiyam*, the diameter of the earth and moon were given as 1050 and 315 yojana respectively. In the *Brahmasphuṭasiddhānta* (628 A.D.)[104] and *Siddhāntasiromaṇi* (1150 A.D.), it is rendered as 1581 and 480 *yojanas* respectively.[104] The *yojana* of *Āryabhaṭiyam*[79] was taken as equal to 7½ miles (12.07 km) and the *yojana* of *Brahmasphutasiddhānta*[104] was considered as 5 miles (8.05 km). So the diameter of earth and moon according to *Āryabhaṭa* would be 7875 miles (11700.95 km) and 2362½ miles (3803.62 km) and according to Brahmagupta they would be 7905 (12727 km) and 2400 miles (3864 km) respectively. It may be interesting to note that the actual equatorial diameter of earth is 7927 miles (12762.47 km) and polar diameter is 7900 miles (12619 km) and the diameter of the moon is 2162 miles (3480.8 km). This closeness of the data, however, may be due to eagerness of the scholars to prove that the ancient astronomical works have given the accurate data. If we really take into consideration the equation of Āryabhaṭa in relation to *aṅgula* and *yojana*, then one can note considerable disparity as can be seen from the following details.

Āryabhaṭa in Daśagītikāsūtra of *Āryabhatīyam* has stated the diameter of earth and moon as 1050 and 315 *yojanas*[90] respectively. He has also stated that a *yojana* was of 8000 *puruṣas* (96 *aṅgula* for *puruṣa pramāṇa*). When calculated on this basis, according to him the diameter of earth and moon will be 9535.4 miles (15352 km) and 2863.3 miles (9609.43 km) respectively.[103]

Bhāskara's calculations widen the error still further. Since Bhāskara himself has stated in *Līlāvati*, that 8000 *daṇḍas* or 768,000 *aṅgulas* were a *yojana*[49], the *yojana* can be calculated on the basis of 12.12 miles (19.5 km) or 9.09 miles (14.58 km) depending on whether his *aṅgula* is equal to 1″ or 3/4″ respectively. The calculations shown in the Appendix I indicates to a certain extent, the length of the *yojana* as considered by different authors, in terms of miles and kilometres. It appears to vary between 1 mile (1.56 km) to 13½ miles (21 km) according to different writers.

As has already been stated, considering an *aṅgula* as equal to be 1″, the *yojana* of Kauṭilya comes to 6.06 miles (9.7 km) and that of the others to 12.12 miles (19.5 km). According to Bakṣali manuscript which refers to an *aṅgula* as 6 *yavas*[105] (3/4″), the *yojana* measures 9.09 miles (14.58 km). Taking into consideration, the yoking distance and the army's march, *yojana* of 12.12 (19.5 km) seems to be more plausible.

Measuring by yoking distance is still common in certain places in India. *Kurgi* in Marathi speaking areas is a land measure, which is the distance that may be ploughed and sown in one day, with a pair of bullocks and drill plough. The extent varies from two to eight acres. *Kurige* in Kannaḍa is a seed drill or sowing machine drawn by oxen. *Kurige* also is a land measure like *kurgi*.

The old English word for *furlong* was *furlang* (660 ft) and was derived from *furh* meaning furrow and *lang* meaning long. Thus the furrowing length was considered as furlong. It is, therefore, interesting to note measuring by yoking distance was in vogue in other parts of the world also.

For the sake of completion of the information available on the linear measures in ancient India, two novel linear measure tables described by Bhoja in his *Yukti-Kalpataru*[106] are given below. The first table is a kind of novel measurement used in the design of several Royal appendages. Here, each succeeding measure form a multiple of ten with regard to the one preceding it (a decimal system).

10 hastas	=1 Rāja hasta (hasta of the King)
10 Rāja hasta	=1 Rāja daṇḍa
10 Rāja daṇḍa	=1 Rāja catra
10 Rāja catra	=1 Rāja kaṇḍa
10 Rāja kaṇḍa	=1 Rāja puruṣa
10 Rāja puruṣa	=1 Rāja pradhāni
10 Rāja pradhāni	=1 Rājakṣetrama

The other table relates to nine times the preceding measure

9 tantu	= 1 sūtra
9 sūtra	= 1 guṇa
9 guṇa	[illegible] śa
9 pāśa	[illegible] aṣmi
9 raṣmi	= 1 rajju[106]

These equivalents were not mentioned by any other writer. Even Bhoja himself has not mentioned these in his *Samarāngṇa sūtradhāra.*

Before concluding, a comparison of the evolution of the Indian linear units with the evolution of British units will not be out of place.

The inch (2.54 cms), which corresponds to the Indian *aṅgula* (8 yava=1″) was introduced in Britain during Roman occupation as a thumb's breadth. It was 1/12th of the foot in the Roman duodecimal system.

The yard of 36 inches has its origin in the Tudor times. By tradition (often stated as fact), Henry VII, in the 16th century A.D., is supposed to have decreed, that the yard should thenceforth be the distance from the tip of his nose to the end of his thumb with the hand stretched fully. It is half *vyāyāma* of the Indian system.

The mile was defined by the Romans as 1000 paces, each pace being equal to 5 Roman feet. This mile of 5000 feet later became the English mile, possibly in the reign of Henry VII, but definitely through a statute of Elizabeth I, as measuring 5280 feet. This mile corresdonds to 1000 *prakramas* of ancient Indian literature.

A study into the different scales of ancient India along with the scales of Gudea and Sankereh tablets also reveal certain common features. The scales of Harappa[4] and Mohenjo daro[2] reveal the use of both binary and decimal systems. The foot and the cubit measures [13.2″ (39.5 cms) and 20.7″ (52.6 cms)] found in Harappa and Mohenjo daro correspond to the units of ancient Egypt. The houses in Lothal can be measured in terms of foot, the unit in each case being 13.2″ (39.5 cms). The rules of Gudea are engraved scales showing a resemblance with the Assyrian span scale of 10.8″[8] (26.4 cms), while Sankereh tablets reveal use of decimal systems.[6] The general

statement, the binary and decimal systems were prevalent in India, however, does not seem to tally with the literature. Decimal system can be seen, only in the bigger units in Karṇāṭaka, where the villages are grouped together in hundreds and thousands, namely Belvala 3000, Bānāwasi 12,000, Nolambāvadi 32,000 and Gangāwaḍi 96,000 etc. Perhaps, these are all in accordance with *Mahābhārata, Manu* and *Viṣṇu Smṛtis*, where for administrative purposes, the grouping of 10, 20, 100 and 1000 were advised. Here also, these divisions might probably be only an approximation. Instead of expressing numbers like 2986 or 12012, the round numbers like 3000 and 12000 might have been conveniently used.

The prevalence of quarternary system perhaps might have been found easier for calculation and particularly for division. Moreover, since almost all the linear measures prevalent were derived from the parts of human body the decimal system was not possible. For example, we had measures like span which was 1/8th of the human body and cubit was 1/4th of the body. The various measures derived from human body are shown in Plate I.

Aṅgula, aṅguṣt or *digit* seems to have been the most important unit and even the minute variations in this unit, created a vast difference in the bigger units. In ancient India a *hasta* or the cubit seems to have been the basic unit, for expressing the linear measures.

The measure smaller than the *aṅgula* namely *aṇu, trasareṇu, rathareṇu, vālāgra, liksa, yuka,* and *yava* follow octonari system. The bigger units *pada* (6 *aṅgulas*), *vitasti* (12 *aṅgulas*), *aratni or hasta* (24 *aṅgulas*), *vyāyāma* (84 *aṅgulas*) and *daṇḍa* (96 *aṅgulas*) seem to follow duodecimal system. If *yojana* is considered as 4 *krośas*, then it can even be stated as being quarternary in relation to the bigger units also.

Finally, it will be interesting to note that in using the various parts of the body for measuring, a remarkable coincidence is seen with the measures found in Babylon, Egypt and Rome, as brought out in Chart II. This chart also brings out all the relevant equivalents of the linear measures used by different writers in the past in India.

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3

Area Measures in Ancient India

THE evolution of area measures in ancient India appears to have started far later than the evolution of linear measures. While the references to linear measures, can be traced to early Vedic period[1], the earliest reference on area measures, appears to be seen in *Baudhāyana dharmasūtra*[2], which belongs to 1000 B.C. The need for area measures seems to have arisen in relation to gift of lands. Even though entire villages were granted by charter on many occasions, a large number of land gifts appear to be related to smaller plots of land necessitating the measurements to be indicated in the records. The information about area measures, though available in ancient Indian literature and inscriptions, are not often comprehensive and there is considerable uncertainty about the exact area, which many of the land measures used in those periods, actually represented. Further, no common standard appears to have existed in ancient India on area measures. The same unit appears to have had different values in different places at the same period and also at the same place in different periods. This naturally makes it difficult, for anyone to correctly project an evolutionary pattern, in defining the development of area measures in ancient India. The present attempt tries to bring together, most of the relevant information relating to the area

measures, used in different places in India at different periods and attempt to link them to some commen base.

An examination of the various area measures used in ancient India, brings out the fact that four different approaches were made in demarcating land areas:

1. The most commonly used approach appears to be related to the use of a variety of *dandas* of definite *hastas* (cubits). The most common measure belonging to this category was *nivartana*. Many other measures using different rod measures were in use particularly in South India such as *mattar, kamma, paṭṭi*, etc.
2. The second approach was by plough measures as *hala, vādha, sīrā*, etc.
3. The third approach was related to the quantity of seed sown as in *kulyavāpa, āḍhavāpa, drōṇavāpa*, etc.
4. The fourth approach was according to the yield of land as in *bhūmi*.

The information on various measures in each of these categories are presented in their order of popular use and the details on these are given in a chronological order, to understand the varying concepts relating to these measures from time to time and in different regions in ancient India.

Nivartana (*niyattana* of Jain texts): This is the most extensively used term for area measure in the literary and epigraphic records. However, it seems to vary considerably in the size of the area it denoted in different records. The earliest reference to *nivartana* occurs in *Baudhāyana dharmasūtra* (third praśna). In this, a brāhmin was described to be cultivating six *nivartanas* of fallow land to support his family, giving a share to the owner also. The term used for this is *ṣaṇṇivartani*[2]. Here the area was not defined clearly except to state that the brāhmin ploughed it with two bulls.

In *Śātātapa samhita*[3] and *Bṛhaspati samhita*[4], a *nivartana* is described as representing an area of 30×30 sq. *daṇḍas*, with the length of the *daṇḍa* being 10 cubits. Therefore, according to them a *nivartana* is 300×300 cubits, which will be equal to about 4.5 acres (1.8 hectares). Kauṭilya, also considers *nivartana* as being equal to 3 *rajjus* or 30 *daṇḍas*, but he has a different measure for the *daṇḍa*. According to him, each *daṇḍa* measured 192 *aṅgulas* as specified for gifts to brāhmins.[5] Thus, his *nivartana* would be 160×160 sq. yds, which would be equivalent to about 5 acres (2 hectares) assuming that an *aṅgula* was equal to an inch. If his *aṅgula* is considered as equal to ¾ inch as mentioned by some authors, then it would be 120×120 sq. yds which would be about 3 acres or 1.2 hectares only. Kauṭilya also described a *daṇḍa* of 96 *aṅgulas*, in which case the *nivartana* area will be half of the above calculations.

Śukranīti[6], quoting Prajāpati and Manu gives two different equivalents for *nivartana*. According to Prajāpati and Manu as quoted in it, a *nivartana* was equal to 25×25 *daṇḍas*, but they differed in their concept of the length of a *daṇḍa*. Prajāpati considered a *daṇḍa* to be equal to 5 *hastas*, while that of Manu was 4 *hastas*, making a *nivartana* being equal to about ¾ acre and ½ acre (0.3 and 0.2 hectares) respectively.

In Nīlakaṇṭha's commentary[7] on *Mahābhārata* a *nivartana* was described as 20 rods (probably 20 rods each way). The actual length of the rod is not clear.

Vijñāneśwara[8] in his *Mitākṣara*, also referred to *nivartana* as 30 *daṇḍas* square. However his *daṇḍa* was of 7 *hastas*, thereby making a *nivartana* equal to 210×210 cubits (about 2¼ acres or 0.9 hectares). The same opinion is adhered to by Ballālasena in his *Dānasāgara*[9].

Hemadri's *Caturvargacintāmaṇi* is a valuable lexicon quoting several authors on different subjects. *Dānakhāṇḍa*[10] in that work is a veritable compendium on giving gifts, wherein he quotes *Matsyapurāṇa* as holding the view, that a *nivartana* is 210×210 cubits square. However, in his *Vratakhāṇḍa*[11], he indicates that the *daṇḍa* according to Bṛhaspati was of 10 *hastas*, while according to *Matsyapurāṇa* it was 7 *hastas*, thereby once again the two views namely, a *nivartana* being 300×300 cubits according to one and 210×210 cubits according to another are presented.

The later mathematical works of repute, instead of clarifying the position relating to the actual area representing a *nivartana*, added further confusion by different writers giving entirely different values. Śrīpati in his *Gaṇitatilaka*[12] states, that a *nivartana*, is of 2 *rajjus*, a *rajju* being 20 *daṇḍas*. This makes it equal to 160×160 *hastas*, giving an approximate value

of 1½ acre (0.5 hectares) for a *nivartana*. Bhāskarācārya[13] considered it to be of 20 *vamśa* square and his *vamśa* was equal to 10 *hasta* making it 200×200 *hastas* or nearly 2 acres (0.8 hectares).

In the Gujarati commentary on Śrīdhara's *Pāṭīgaṇita*[14], the term *netana* is used, which is probably a local term for *nivartana* and is said to represent 312×312 *hastas*, which will be about 5 acres (2 hectares). Till as late as 19th century A.D., a *netana* measure corresponding to 5 acres (2 hectares) was in use in Bihar.[15]

Situation is the same, even in relation to the inscriptional references relating to *nivartana*. Inscriptions covering almost all over India at one time or other refer to *nivartana*. Inscriptions of Sātavāhanas[16] Vākātakas[17], Pallavas[18], Kadambas[19], Cālukyas of Badāmi[20], Kalachuris[21], Rāṣṭrakūṭas[22], Cālukyas of Kalyāṇi[23], Paramāras[24], Gahadvālas[25], Yādavas[26] and their feudatories refer to *nivartana* in their grants.

The earliest record to mention *nivartana*, was from Nasik cave inscriptions[16]. Rājan Gautamiputra Sātakarṇi donated 200 and 300 *nivartana* of land to the mendicant ascetics. In the Hīrahaḍagalli grant (1st quarter of 4th century A.D.) of Śivaskandavarman, two *nivartanas* of land in the village of Apitti were given as gift.[18]

Nivartana appears to have been measured by different *daṇḍas* at different places. In the Godachi plates of Kattiaraśa dated 578 A.D., twenty-five *nivartanas* were measured by the royal standard (*rājamāna daṇḍa*)[27]. In the Kolhapur inscription of Śilāhāra Vijayāditya (Śaka 1055), a grant of ¼ of a *nivartanas* was measured by *Kuṇḍi daṇḍa*.[28] In another inscription from Kolhapur during the time of Bhoja II (Śaka 1112-1115), terms *uttamā nivartana* and *kaniṣṭha nivartana* occur.[29]

In certain land grants, vague references are made about the measurement of *nivartana*. In the Abhona plates of Śaṅkaragaṇa (Kālachuri Samvat 347), a grant of 100 *nivartanas* of land in the village, Vallisaka in Bhogavardhana viṣaya is recorded.[21] "*Ubhaya Catvārimśaka nivartanina bhuminnivartanaśatam*" is understood by V.V. Mirashi as forty *daṇḍas* on either side i.e. 1600 sq. *daṇḍas*. Here, the length of the *daṇḍa* is not mentioned.

In the Kadambapādraka grant of Paramāra king Naravarman, 20 *nivartanas* of land were measured with a rod, and the land was 96 *parvas* in length and 42 *parvas* in breadth.[24] The measurement of the *parva* is not mentioned. If a *parva* is equal to 4 *hastas*, then the *nivartana* would be 1.6 acres (0.6 hectares]. All these show that *nivartana* is an area measure and the area it represented depended upon the length of the rod used. *Maruturu* of Telugu records[20] and *mattar* or *mattaru* of Kannaḍa records[31] are considered as terms equivalent to *nivartana*.

The length represented by *daṇḍa* varied from 2, 4 or 8 *hastas* in literature and also from area to area in epigraphical records. Unless the actual length of the *daṇḍa* is clear, it will be difficult to arrive at a proper value for *nivartana* out of the epigraphical records. Still several scholars have dealt with *nivartana*, arriving at different conclusions. One method of arriving at the value of *nivartana* is deducing it from other known measurements. Since Bṛhaspati[4] and Yājñāvalkya[8] have stated that a *nivartana* is 1/10th of a *gocarman*, one can deduce the dimensions of a *nivartana* from *gocarman*. Here also there is no definite accepted relationship. As for example *Matsyapurana* states that a *gocarman* is 2/3 of a *nivartana*.[11] Again, the area represented by *gocarman* is not clear. This will be dealt with in detail while discussing *gocarman*.

In the Nagari plates of Ananga Bhīma III, dated Śaka 1151 and 1152, 18 vāṭis in Pūrṇagrāma were granted to a brāhman Dikṣita Rudrapāṇiśarman.[32] The area of 18 *vāṭis* of land is referred here as a *gocarman*. *Pramoda Abhidhāna*, an Oriya dictionary published in 1942 refers to a *vāṭi* as comprising 20 acres. Since *nivartana* is said to be 1/10th of a *gocarman*, a *nivartana* would be 36 acres according to this. It may be noted that the area represented by *vāṭi* was also not uniform.

According to Wilson's glossary a *vāṭi* of land in Orissa is 20 *mānas*. A *māna* which is otherwise known as *bigha*, is said to be equal to 25 *gunṭhas* in Cuttak. A *gunṭha* (measuring 121 sq. yds. or the fortieth part of an acre in some places) is regarded as 16 *bisvas*, while a *bisva* is 1/20th of *bigha*. Based on this, the *vāṭi* can be regarded as 12½ acres (5 hectares). On the other hand, if 18 *vāṭis* constituted a *gocarman*, then a

nivartana would be 22½ acres (9 hectares). Both these calculations seem to be far off the mark of our ancient seers. Moreover, the 17th century work *Dānamayūka* states that a *gocarman* is 2/3 of a *nivartana*. Thus the approach to arrive at the area of *nivartana*, through its relationship to *gocarman* of *vāṭi* adds to the confusion only.

One scholar concludes, that since the term *nivartana* literally means 'turning back' it probably indicates measuring of lands by an individual, starting from a particular point, going round the field and returning to the starting point within a certain time, thereby marking the exact boundary of the field covered, during the course of the round. A similar custom seems to have prevailed in Russia also. The Baskeers were said to have the habit of selling land by the day, i.e. as much of land as a man can go round on his feet, from sun-rise to sun set. Naturally, the area it represents is bound to differ, since the rate of walking differs from individual to individual. Perhaps the distance covered by a certain individual in a day, might have been used as the standard.[33] However these are only conjectures.

From the Kasakuḍi plates of Pallava Nandivarman II, it seems *nivartana* and *paṭṭi* are synonymous. The Sanskrit portion of the plates '*Sāmanya nivartanadvaya maryādaya*' is a literal translation of the Tamil portion of the same grant '*Samānya renḍu paṭṭipaḍiyal*'.[34] No deduction can be made from these statements, since the exact area of a *paṭṭi* is not known.

According to P.V. Kane the word *nivartana* was derived from the root 'vrit' meaning encompass or surround with the prefix 'ni' and hence it is an area ploughed in a day by a team of six or eight oxen[35] (ni=six or eight). Dr. D.S. Bose has come to the conclusion that the sq. *nivartana* of Brahma, quoted by Śukra is equal to 2500 sq. yds. (0.2 hectares), while in the *Arthaśāstra* it is equal to 3600 sq. yds. (0.3 hectares)[36] Dr. Pran Nath suggest, that *brahmadeya nivartana* is the area of land granted to a brāhman and is equal to an English acre.[73] Dr. Altekar takes as 5 acres (2 hectares)[38] and Dr R.S. Sharma

considers it as 1½ acre (0.6 hectares).[39] Dr. S.K. Das states that *nivartana* is an area sufficient to support one man from its produce.[40]

All these differences appear to be mainly due to the varying length of the cubits and the measuring rods used by different people without any recognized standard. Even at present, in different areas the measuring rods and areas represented by the term *bigha* differ. Bombay *bigha* (3925 sq. yds.) is equal to about 2½ Bengal *bigha* (1 Bengal *bigha*=1600 sq. yds). Thus *nivartana* seems to vary from 5 acres to 0.5 acres (2 hectares to 0.2 hectares) in different periods at different places.

Gocarman has been mentioned in many of the literary works cited above. *Gocarman* literally means the area of land, that could be covered by the hides of cow slaughtered in a sacrifice and was granted as the priest's sacrificial fee.[41] The term *gocarman* has been interpreted in different ways. It is said to indicate a piece of land large enough, to be encompassed by straps of leather from the hide of a single cow, according to Nīlakaṇṭha's commentary on *Mahābhārata*.[42] According to *Parāśara Samhita*[43] and *Bṛhaspati Samhita*[44], *gocarman* is that area of land, where one thousand cows could freely graze in the company of hundred bulls (or one bull). Another, variant reading of Bṛhaspati, quoted by Hemadri in *Vratakhāṇḍa* states, the *gocarman* is equal to 80 *nivartanas* and a *nivartana* is of 30 rod (square), with the rod measuring 10 cubits. *Śātātapa samhita* agrees to the same.[45] Vijñāneśwara slightly differs by stating that the *daṇḍa* measures 7 cubits.[8] According to the former it will be 45 acres (18 hectares) and the latter it will be 22½ acres (9 hectares) approximately.

In contradiction to these, Hemadri quoting from *Matsyapurāṇa* in his *Dānakhāṇḍa* section states, that a *gocarman* is 2/3 of a *nivartana*. In the same section he refers to Vaśiṣṭha having stated that a *gocarman* is 150×150 cubits.[10] According to these calculations *gocarman* may be close to a hectare (2.47 acres). Vṛddha Vaśiṣṭha and Parāśara (quoted by Hemadri in *Dānakhāṇḍa*) indicate that hundred cows and a bull can occupy a *gocarman*.[10] According to *Viṣṇu Samhita*,

gocarman is that much of land of whatever extent, the crops raised on which will maintain a man for one year.[46]. Like Hemādri, Aparārka also quotes most of these concepts. According to Monier Williams and Wilson, *gocarman* is the land measuring 300×10 ft; but this statement does not coincide with any of the authorities quoted above. Thus the area represented by the term gocarman is very confusing.

The term *gocarman* mainly occurs in Eastern India in the grants of Ganga kings. In the Nagari plates of Ananga Bhima III (Śaka 1151, 1152). the area of 18 *vāṭis* is referred to as *gocarman*.[32] A *vāṭi* in Orissa is equal to 20 *mānas* or 20 bighas according to Wilson's glossary as referred to earlier. Hence a *vāṭi* is 12½ acres. The Oriya dictionary Pramoda Abhidhāna (published in 1942) however, regards *māra* as equal to one acre and *vāṭi* therefore will be equal to 20 acres. Hence *gocarman* must be either 225 acres according to the former and 360 acre according to the latter, both representing a large areas. Perhaps these may be comparable with the statements of Bṛhaspati and Parāśara. *Gocarman*, perhaps, may be derived from *gocara* meaning the grazing field of the cow. Pasture lands, which cannot be cultivated, might have been donated as large areas to people. The area of a *gocarman*, if it is taken in this sense, can only be an approximate measure indicating a vast area.

Mattal, *mattar* (Kannaḍa), *martu*, *marturu* or *maruturu* (Telugu) are common terms used for measuring lands in Karṇāṭaka and Andhra Pradesh.

There is a vague reference in an inscription from Udari, where it is given, that 100 *kammas* as being equal to a *mattar*.[47] This reference relates to one Heggade Rajaya's son, Heggade Timmana, and daughter Heggade Chandave, who got a temple of Sakaleśvara constructed and for the feeding of the brāhmans and for offering boiled food to God, had granted 53 *kammas* of rice land and 50 *kammas* of wet land, aggregating to 1 *mattar*. Another epigraph from Balambige refers to '*kamma* 50 *kammas* 50 *antu mattarondu . . . kamma* 60 . . . *kamma* 40 *antu mattarondu*' suggested that 100 *kammas* constituted a *mattar*.[48]

Another inscription dated 1218 A.D., equates 2 *hādas*+35 *kambas*, 1 *hāda*+35 *kambas*+35 *kambas*+35 *kambas* totalling 3 *hādas* and 140 *kambas* with 2 *mattars* 15 *kambas*.[49] This, therefore suggests 100 *kammas* or *kambas* are equal to a *mattar*. There are several other inscriptions mentioning gifts of 145 and 175 *kammas*. It may be a way of expression or the term *mattar* may perhaps be more than 100 *kammas*. It is interesting to note from the Talgunda inscription that one *mattar* of land was taken to yield two *khaṇḍikas* or *khaṇḍugas* of grain.[50]

For the measurement of *mattar* several rods (*daṇḍa* or *gale*) such as *Rājamānadaṇḍa*[51], *beruṇḍa gale*, *agradimba gale*[52], *Dhānavinodha gale* (35 spans), *Ovantaramalla gale* (13 span)[54], *Bhūguda gale* (28 span), [53] *Kiriya gale* (small rod), *Tāmbla gale* (Tamil Country), etc,[44] were used. In the Salotgi inscription, it is mentioned, that Mahāmadaleśvara Gounarāsa gave to the God Traipuruṣa at the agrahāra of Panithage, in the Badala thirty six, two hundred *mattars* of cultivated land, measured by the *Tāmbla* rod; two *mattars* of land in Bālambige, measured by *magau rod*; and three *mattars* of paddy fields measured by small (*kiriya*) rod in Singanakaṭṭe near Makiriyinti.[23] Similarly in an inscription from Yewur several *mattars* were measured by *Dhānavinodha gale*, *Elave gale* and *Ovantara gale*.[54] These show that several rods were used for measuring the *mattar* by the same person in the same gift of lands even in the same area.

In the Western Cālukyan records the term *gaunigana mattar* occurs.[55] In an inscription of Vikramāditya VI, dry land measuring 40 *kāla mattars*, were given away as gift.[56] *Kai mattar* is another term found in the Karnāṭaka records.[57] *Marṭu*, *marturu*, *matturu* or *maruturu* are the Telugu counter parts for the term *mattar*. Though these terms were generally used for measuring wet land, it was not quite rigid. In the Hanamkoṇḍa inscription (Śaka 1001)[58] and Bothpur inscription (Śaka 1181)[59] *maruturu* is associated with both dry and wet lands. *Marutelu* and *martulu* are the plural forms of *marturu* and sometimes the word *mā* itself referred to *marturu*. Several types of *maruturu* occur in the records from Andhra Pradesh. *Miṭṭa-kommu martuturu*[60] might refer to some field in a higher level since miṭṭa is high or rising ground. *Pahimdivaya maruturu* may be a certain measure of land, which brought an

income in cash and not in kind.[61] *Ghaḍa maruturu*[62] and *kunta maruturu*[63] are other types of *maruturu.* All these inscriptions are, however, silent about the area of the land these terms covered.[64]

Kamma or *Kamba,* undoubtedly is smaller than a *mattar* mentioned in the inscriptions from Karṇāṭaka.[65] Literally this term means a rod or a stick, derived from the Sanskrit word stamba.

Paṭṭi is a common land measure in extreme South. This term is also used in Gujarat. It also means a sheepfold or a plot of land. In South, the names of the villages and hamlets often end with the suffix *paṭṭi,* thereby denoting an area of land. *Paṭṭi* also denotes a pole in Karṇāṭaka and different poles were used for measuring different soils. One pole or *paṭṭi* was used for black soil and other for masab or mixed soil and a third for tari or rice land. Within each classified soil also, the area represented by *paṭṭi* appears to have differed. As for example in black soil the pole or *paṭṭi* varied from 24 to 48 *kurgis* or drill plough's day's work.[66a]

Paṭṭi is referred to as a piece of land in Halsi grant of Ravivarman.[66] In the Gorantla plates a gift of 800 *paṭṭis* of land at the village of Tanlikoṇḍa is recorded.[67] In the Candalur grant of Kumāraviṣnu out of 800 *paṭṭikas* of land at the village of Candalur, the king offered 432 *paṭṭikas* as brahmadeya, gift to brāhmans.[68] Several *paṭṭikas* occur in the Kaira grant of Cālukya Vijayarāja[69], which indicated the use of the term *paṭṭi* in Gujarat also. Till recently in Karṇāṭaka the *paṭṭi* varried from 24 to 48 *kurgis.* According to the soil, one *kurgi* varied from 2 to 8 acres. Further, it is difficult to conclude about the area represented by the term *paṭṭi,* since the variations relating to the soil types appear to be too many. As stated earlier from the Kasakuḍi plates of Pallava Nandivarman, *paṭṭi* and *nivartana* appears to be synonymous. This has been referred to under *nivartana.*

Kuḻi which literally means a pit, is used as a unit for area measure in extreme south only. *Kuḻi* was measured by different types of koles (measuring sticks) namely *Kaḍigaikuḷattukkol*[70], *māḷigaikol*[71], *nālucānkol* (4 span)[72], *pannīrucān kol* (12 span), *padinārucānkol* (16 span)[73], etc. During the

time of Nṛpatuṅgavarman in an inscription, it is stated that 27,000 *kuḻis* of land were divided among various people, each *kuḻi* measured by a *pannīrucānkol* (12 span rod). Therefore in the time of Nṛpatuṅgavarman, a *kuḻi* must have measured $[12\times\frac{3}{4}]^2 = 81$ sq. ft.

However, *kuḻi* measure is known to have varied from 144 sq. ft. to 576 sq. ft. in Karnāṭaka, Kerala and Tamiḻnāḍu. It is also considered as 1/240 of a *pāḍagam.*

Mā stands for tne fraction 1/20 in Tamiḻnāḍu and Kerala in their mathematical tables. Hence Dr. D. C. Sircar considers 1/20th of a *veli* or 2.5 *kāṇi* or 2 *sei* as *mā.* In one of the inscriptions from Tiruvāvadudurai, during the time of Rājendra I (regnal year 6), a *mā* was considered as equal to 100 *kuḻis,* measured by *māḷigaikol.*[71] Till recently in Tamiḻnāḍu and Kerala *mā* was equal to 240 *kuḻis* (3.17 acres, 1.3 hectares), which was the same as *pāḍagam.*

The measures described above are the measures using daṇḍas or *hastas* as the linear measure units. The following area measures were derived from plough measures, which was another system used for measuring cultivated lands.

Hala literally means a plough. A large plough was known as hali, jitya, lāṅgala and śirā according to Pāṇini. But whether all these expressions were used as units of measurement is not clear. *Dvihalya* and *trihalya* mentioned by Pāṇini appears to represent areas cultivated by two or 3 ploughs respectively.[75]

Manu refers to various kinds of ploughs. His commentator, Kullūkabhaṭṭā explains, that the area measure using a plough drawn by eight bullocks as *dharma hala,* that drawn by six for the cultivators (*madhyama hala*), that drawn by four was used for house-holders (*gṛhasta hala*) and the one drawn by three bullocks used for the brāhman (*brahma hala*)[76]. *Atri samhita* however, refers to four kinds of *hala* drawn by eight, six, four and two bullocks.[77] Bṛhspati has stated that a *hala* should be eight *aṅgulas* long and four *aṅgulas* broad[78]; but he has not specified *hala* as a land measure. The statement by Bāna that "Harṣa bestowed hundred villages, delineated by thousand ploughs" can refer to either the extent of land given away in hundred villages measured by thousand ploughs.[79]

It is difficult to ascertain the exact area that could be culti-

vated with one plough. If the soil presents a congenial condition and if the oxen are healthy, the area is bound to be more. The size of the plough is also an important factor in determining the extent of the land that can be ploughed in a given time. As the grades of soil were of different categories and the size and the capacity of the oxen also differed, the extent of the plough measure could not have been uniform throughout. When plough (*hala*) occurs as a measurement, it refers to that much of a land which can be cultivated by a plough in a given time at the given place. Only the time factor could have remained uniform.

Epigraphic evidence of *hala measure* usage are available in plenty. The term hala occurs in the inscriptions of many dynasties like Śātavahanas[80], Pallavas[81] Rāṣṭrakūṭas[82], Cālukyas[83], Paramāras[84], Kalachuris[85] and Cāhamānas.[86] In a Prākṛt inscription from Nāgārjunakoṇḍa, pertaining to the time of Mahātaḷavāri Aḍavi Catiśri and Śrī Cātamūla, the former gave away hundreds of thousands of ploughs of land'.[80] In the Pallava grant of Śivaskandavarman (4th century A.D.) a lord Bappa was called the bestower of 100,00 ox or cow ploughs.[81] In these cases, either the *hala* used may be smaller one, mentioned by Bṛhaspati or just poetic exaggerations.

The term *bhikṣu hala*, occurs in one of the Kārla cave inscription.[87] Hieun Tsang has stated that the lands, which were given to the Saṅgha, were under the control of monks. Since the monks were not agriculturists, the lands were allotted to agriculturists, who had to give 1/6th of the produce from that land to the Saṅgha. The Saṅgha had to provide bulls, the land for cultivation etc., but was not responsible for any other requirements.[88] Perhaps the measure used for this may be like *brahma hala* or as in the case of *brahmadéya daṇḍa* in the land grants to brāhmans, a liberal measure might have been used.[13]

In the Paithān plates of Rāṣṭrakuṭa Govinda III (794 A.D.), the term *grāma hala* occurs, which indicates the measure used in that village.[82] The Udayendiram plates of Nandivarman (8th century A.D.) refer to *bhōga hala*.[81] In the Harṣa stone inscription of the Cāhamāna Vigraharāja of V.S. 1030 (970 A.D.) a term *bṛhad hala* occurs.[86] In the Bhatera plates of Govinda Keśavadeva (1044 A.D.) and Mahārāja Yaśovarmadeva the term *bhū hala* occurs.[89] These indicate the existence of *hala* measures of different sizes apart from the *hala* measures related to different number of cows or oxen used.

The term *halavāha* used in the Bombay Asiatic Society copper plate of Bhimadeva II[90] and Paramāra Dhārāvarṣadeva[84], means that much of land that could be ploughhd with one plough. The Hathal inscription of Dhārāvarṣadeva (V.S. 1237) refers to an area of land that could be ploughed with two ploughs.[91] The Charkhari state inscription of Paramārdideva, records a grant of land which could be tilled by five ploughs in a day.[92]

Haele seems to be of a local variations of the term *hala*. In the Sanderav stone inscription of Kelhaṇadeva (V.S. 1221) of the Cāhamāna dynasty of Sambhar, Analadevi granted one *haele* of Yugandhari and that some rathakāras also granted another *haele* of Yugandhari. This may perhaps mean the yield of jowar in the land. *Hara* used as corn measure in Kathiawar may also perhaps be a variation of *hala*, which may also mean the produce by a *hala*.[94]

In a copper plate of Candella Madanavarmadeva, 7½ *drōṇas* of seed are stated to have been used for sowing 10 *halas* i.e. one *hala* required 3/4 *drōṇa* of seed.[95] A *hala* cultivated 34 *amśas* in Depalpur at the time of Bhoja Paramāra.[96] In the Sunak grant of the Cālukya king Karṇa, it is stated that 4 *halas* of land, required 12 *pāilam* of seed corn for sowing. Hence 1 *hala* required 3 *pāilam* or 12 *seers* of seed.[83] Plough measure is still current in some areas. *Kurgi* in Marathi is a land measure that refers to that much of a land ploughed in one day with a pair of bullocks and a drill plough, the extent varying from two to eight acres. According to Buchanan, the usual extent which can be cultivated by one plough is 10 large *bighas* or 15 Calcutta *bighas* of 5 acres (2 hectares)[97]. In Sylhet district, *hala* corresponds to about 10½ *bighas* or 3½ acres (1.6 hectares). One plough cultivates 10 large *bighas* or 5 acres (2 hectares) in Dinajpur and 6 acres (2.4 hectares) in Orissa while in South India it will be 2½ acres (1 hectare) of wet land and 5 acres (2 hectares) of dry land.

Sri Padmanath Bhattacharya gives the following table relating to the measures in Sylhet.

7 cubit	=	1 nala
1 nala × 1 nala	=	rekhā
4 rekhā	=	yaṣṭi
28 yaṣṭi	=	kedāra
12 kedāra	=	hala

Thus according to this table *hala* will be equal to 65,856 cubits that is 3.4 acres[98] (1.5 hectares).

Vādha is an unusual term occuring in the Mahoba plates of Paramārdideva, where it is stated that 5 ploughs could cultivate 60 sq. *vādhus*.[99] Therefore 12 sq. *vādhas* could be cultivated by 1 plough. Dr. Pushpa Niyogi arrived at the conclusion, that a *vādha* is equivalent to 1371.33 sq. yds.[94]

Sīrā occurs in *Ṛgveda, Taittiriya Brāhmaṇa* and *Vājaseniya Samhitā*, and Pāṇini's grammar meaning a plough.[100] In the Rahan copper plates of Madanapāla and Govindacandra the term *sīrā* denotes the extent of land cultivable by four ploughs.[25]

Kula is an enigmatic term mentioned by Manu.[101] According to the commentators Govinda, Kullūkabhaṭṭa and Rāghavānanda, *kula* or *kulya* is as much of land as could be cultivated by two ploughs. Nandana, however, interprets *kula* as the share of one cultivator.[102]

In this connection it will not be out of place to refer to the furrow length, which was termed as furlong in Britain. This was in use, till recently which indicates that plough measures were in use in other countries also.

There are many area measures which relate to the quantity of seeds sown. In many of the inscriptions, the terms like *pāṭaka, kulyavāpa, drōṇavāpa, āḍhavāpa, khārivāpa, pravartavāpa, unmāna* or *udamāna, khaṇḍika*, or *khaṇḍuga, mūda*, etc., which indicate the measure of quantity sown. This system appears to have been followed till recently in many areas. In Tamil speaking areas the term *kottai viraippāḍu* stands for the area required to sow a *kōṭṭai* of paddy (21 *marakkal*), and it is said to be equivalent to 1.6 acres (0.6 hectares).

In north Arcot district in Tamilnāḍu, the measurement *kāṇi* is based upon the sowing capacity, which differs for

irrigated and unirrigated lands in the ratio of 5:24. Irrigated lands required 7½ Madras measures (Madras measure having a stuck capacity of 105 c.m.) and unirrigated land required 36 Madras measures for sowing[103] per *kāṇi*.

Kulyavāpa, āḍhavāpa and *drōṇavāpa* are terms mainly mentioned in the inscriptions from Bengal. It is hardly seen in the literary records, except in the lexicons. According to Kullūkabhaṭṭa (15 century A.D.), the commentator of Manu, *kulya* or *kula* is as much of a land that can be cultivated by two ploughs.[101] The word *kulya* also means a winnowing basket and *vāpa*, the act of throwing or scattering. Therefore, the term *kulyavāpa* appears to be associated with the *kulya* measure of seed.

There is a controversy among scholars as to whether these terms *kulyavāpa, āḍhavāpa* and *drōṇavāpa* are to be considered as the lands, which could be sown either by a *kulya, āḍhaka* or *drōṇa* quantity of seeds either directly or by transplanting the seedings coming out of these quantities of seeds. The following information supports the view, that these measures represent the quantity of the seeds sown. Lexicographers, Medini, Viśva and Hemacandra mention that 1 *kulya*=8 *droṇa*=32 *āḍhaka*. *Kulya* does not find its place in mathematical works, but the measure *khāri*, equivalent to 16 *drōṇas*, has found its place and so also *āḍhaka*, which is considered as equal to 4 *prasthas*. According to Amara, the word *khārivāpa, drōṇavāpa* and *āḍhavāpa* indicate the area of land that could be sown with seed grains of one *khari, drōṇa* or *āḍhaka*. Almost the same terminology was used by Hemacandra in his *Abhidhāna Cintāmaṇi*.[104] Modern lexicographers, however, differ with each other. According to Wilson, 1 *āḍhaka* was equal to 4 seers. Hence a *drōṇa* would be 16 seers and *kulya* 128 seers. According to Śabadakalpadruma, a *drōṇa* is equal to 32 seers. Then *āḍhaka* and *kulya* would be 8 and 256 seers respectively. In the Bengali compilation of *Śabdakalpadruma* the equivalents are *āḍhaka*=16 or 20 seers; *drōṇa*=1 maund 14 seers or 2 maunds. Hence one *kulya* would be between 12 to 16 maunds.[105] Monier Williams states that in Bengal, the equivalent of *āḍhaka* is 2 maunds or 164 lbs. This seems to be too big a unit. According to Apte's dictionary *āḍhaka* is 7 lbs 11

ozs, which almost tallies with *Śabdakalpadruma*. Thus the values attributed to these measures varied extensively among different scholars. This is probably because the usages were different in different regions.

Many scholars have suggested different concepts. Pargitar has suggested that transplantation was common and that *kulyavāpa* indicated that area of land which was required to plant the seedlings of paddy seeds of one *kulya* in weight. He explained this from the Faridpur plate[106], where *kulyavāpa* was measured by 8×9 *nalas*, with *kulyavāpa* becoming a little more then an acre ($3\frac{1}{10}$ bighās). He came to this conclusion, by assuming a *nala* as of 16 cubits and a cubit of having 19 inches. But in Pāhārpur plates, the *kulyavāpa* was measured by 6×6 *nalas*[107]. Hence *kulyavāpa* must have been measured by different *nalas* at different places. Sometimes the *nala* of 8×9 appears to have been measured by the hands of a particular person as can be seen by the use of the terms *Dharvīkarma hasta*[108], *Śivacandra hasta*[106], etc.

Dr. D.C. Sircar, analysing the various facts came to the conclusion, that both the systems of planting seedlings and of sowing seeds were prevalent in Bengal. One maund of paddy seeds was required for 3 *bighas* for sowing, while seedlings of the same weight of paddy required 10 *bighas* of land for planting. Seedlings of 1 *kulya* (16 maunds of paddy) required 128 to 160 *bighas*, for plantation. Hence a *kulyavāpa* will be equal to 128 to 160 *bighas*, *drōṇavāpa* 16 to 20 *bighas* and *āḍhavāpa* 4 to 5 *bighas* according to the transplantation concept. However, according to the system of direct sowing seeds these measures would be equal to 38 to 48 *bighas*, $4\frac{1}{2}$ to 6 and $1\frac{1}{8}$ to $1\frac{1}{2}$ *bighas* respectively. Dr Sircar used the following table for his calculations.

8 muṣṭi (8 handful)	= 1 kuñci
8 kuñci (64 handfuls)	= 1 puṣkala
4 puṣkala (256 ")	= 1 āḍhaka
4 āḍhaka (1024 ")	= 1 drōṇa
8 drōṇa (8192 ")	= 1 kulya

The earliest record to mention *kulyavāpa*, as a unit of measurement is in the Dhānaidāha copper plate inscription of Kumāragupta I (432 A.D.)[109] and *drōṇavāpa* in Bāigrām copper plate inscription (448 A.D.)[108] and *āḍhavāpa* in the Pāhārpur grant (479 A.D.).[107]

The relations between *drōṇavāpa* and *kulyavāpa* can be ascertained from the Pāhārpur copper plate inscription. The lands donated in that inscription were $1\frac{1}{2}$ *vāstu drōṇavāpas* at Vaṭa-gohali, 4 *drōṇavāpas* at Pṛṣṭhimapaṭṭaka+4 *drōṇavāpas* at Goṣaṭapuñja+$2\frac{1}{2}$ *drōṇavāpas* at Nitva-gohāli, these all together equal to $1\frac{1}{2}$ *kulyavāpa*, would be 8 *drōṇavāpas*.[107]

In some of the inscriptions, the term *vāpa* is not mentioned, yet the implication is clear from the context, that the term referred to the area of the land in which that much of seed could be sown.[110]

Hemacandra mentions *drōṇika* and *khārika* as synonyms for *drōṇavāpa* and *khārivāpa*.[104] In a copper plate of Paramārdideva dated V.S. 1233, $7\frac{1}{2}$ *drōṇas* of seed was required for sowing a particular land.[111] In the Vāillabhaṭṭaswāmin temple inscription, it is mentioned that 11 *drōṇas* of barley were required for two fields, the areas of which are not otherwise mentioned.[112] According to this inscription, that was the standard in use in Gopagiri. *Kulyavāpa*, *āḍhavāpa* and *drōṇavāpa* are summarized by Dr. Sachindra Kumar Maity as follows:

1 *āḍhavāpa*		=1.2—1.5 *bighas*	=0.45—0.56 acres
4 *āḍhavāpa*	=1 *drōṇavāpa*	=4.8—6 *bighas*	=1.8—2.24 acres
8 *drōṇavāpa*	=1 *kulyavāpa*	=38.4—48 *bighas*	=14.4—17.6 acres
5 *kulyavāpa*	=1 *pāṭaka*	=192—240 *bighas*	=72—88 acre.[113]

Another land measure with the term *vāpa* as the suffix, is *khaṇḍukavāpa* used in the Penukoṇḍa plates of the Western Ganga King Mādhava, in which a grant of a plot of land measuring 65 *kedāras* and 27 *khaṇḍukavāpas* is recorded.[114]

In an inscription from East Bengal a term *pravartha* occurs. Owing to lacuna, the word which follows *pravartha* could not be deciphered. But it can be stated, that the text referred to the purchase of an uncertain area of waste land, measured by *kulyavāpa* together with one *pravarthavāpa*. Since the price for *pravarthavāpa* was two dinaras and the price of waste but cultivable land was four dinaras per *kulyavāpa*, Pargiter concludes that *pravarthavāpa* must be half of *kulyavāpa*.[115] It is

preferable to conclude that *pravarthavāpa* is a fraction of *kulyavāpa*.

In a plate of Subhikṣarājadeva from Pāndukeśvar, the terms *khārivāpa*, *drōṇavāpa* and *nālikavāpa* were mentioned.[116] *Nālikavāpa* is a new term not found in the literature or other inscriptions. Dr Sircar concluded, that a *nāli* must be 1/16 of a *drōṇavāpa*. In Childers' Pāli dictionary *nāli* or *nālika* is explained as the same as Sanskrit *prastha*. It appears to be of varying sizes. Tamiḻ *nāḻi* is said to be smaller than the Sinhalese *nāḷi*, while the Sinhalese *nāḷi* is said to be half as much as the Magadha *nāli*.[117] In the Mādhāinagar copper plate[118] and Sunderban copper plate[119] of Lakṣmaṇasena, *khārika* is mentioned. Perhaps it may be *khārivāpa* of Amarakośa. Evidently it will be better to conclude that *nālikavāpa* is smaller than *drōṇavāpa* while *khārivāpa* is bigger than *drōṇavapa*.

Several Maitraka grants mention another measure *prasthavāpa*.[119a] This may mean a measurement of land with a sowing capacity of a *prastha* of seeds. Since *prastha* is ¼ of an *āḍhaka*, *prasthavāpa* may be ¼ of *āḍhakavāpa*, i.e. 0.4 to 0.5 *bighas*.

It is interesting to note that in almost all the terms ending with *vāpa*, the lands are mentioned as kṣetra and not as kedāra except in the Penukoṇḍa plates of Mādhava. Kṣetra normally refers to a field and kedāra refers to water-logged area. Generally, unless it is a water-logged area, direct method of sowing is adopted. Hence these measures can be considered as referring to the direct method and not the transplantation of seedlings.

Another point to note is that till recently the terms *kulavāy*, *doṇ*, *āḍhā*, are current in the eastern districts of Assam. Though these names sound similar with *kulya*, *drōṇa* and *āḍhaka*, there is hardly any similarity in the areas they represented.

Pāṭaka as a land measure bigger than *drōṇa* or *drōṇavāpa*, is also found in the inscriptions from Bengal.[120] To mention a few examples, in the Ānulia copper plate inscription of Lakṣmaṇasena[121], the land granted was 1 *pāṭaka*, 9 *drōṇas*, 1 *āḍhavāpa*, 37 *unmānas* and 1 *kākiṇika*. In the Gunaigarh copper plate of

Vainyagupta dated 507 A.D., 11 *pāṭakas* of land are referred to as having been donated in a single village. The information given in Gunaigarh plates helps to calculate the equivalent of *pāṭaka* in relation to *drōṇavāpa*. These plates refer to separate lands whose areas are as follows:

Plate	1: 7	*pāṭakas*	and	9	*drōṇavāpas*
,,	2:			28	,,
,,	3:			23	,,
,,	4:			30	,,
,,	5: 1¾	,,			
Total	8¾	*pāṭakas*			*drōṇavāpas*

After mentioning these areas, the grant states that the total area was 11 *pāṭakas*. Hence 2.25 *pāṭakas* is equal to 90 *drōṇavāpa* that is 1 *pāṭaka* is equal to 40 *drōṇavāpas*.[120]

Since 8 *drōṇavāpa* is equal to a *kulyavāpa*, 1 *pāṭaka* will be equal to 5 *kulyavāpa* or 640 to 800 *bighas*. This calculation appears to be hypothetical and improbable, because these grants of lands would be too large an area (11 *pāṭaka* would be 7040 or 8800 *bighas*)[115] for gifting away. If the *pāṭaka* is based on sowing rather than transplanting then it would be 2112 to 2640 *bighas* which also would be a very large area for a gift.

A different calculation emerges for *pāṭaka* in the Śaktipur plate of Lakṣmaṇasena[122], where a brāhman Kuvera was given a gift of 6 *pāṭakas* in Rāghavahaṭṭa, Vārahakeṇā, Vāllihiṭa, Vijaharapura, Dāmaravaḍā and Nimāpāṭaka. The first three together with Nimāpāṭaka measured 36 *drōṇas*. Vijaharapura and Dāmaravaḍā measured 2 *pāṭakas* and the total was 89 *drōṇas*. Hence two *pāṭakas* should be taken as 53 *drōṇas*. Thus the size of the *pāṭakas* appear to differ in different areas. It is not clear as to whether the *pāṭaka* was a land measure or represented a part of a village. According to *Abhidhānacintāmaṇi* it refers to half of a village.[123]

In the Naihāṭi copper plate of Vallālasena the term *bhūpāṭaka* is mentioned instead of *pāṭaka* (7 *bhupāṭakas*, 7 *drōnas*, 1 *āḍhaka*, 34 *unmānas* 3 *kākas*).[124]

From all these we can only conclude that the term *pāṭaka* refers to an area far bigger than hectare or even part of a village.

Unmāna or *udamāna* or *udāna* is a common measure mentioned in the inscriptions of Bengal.

From the Naihāṭi copper plate of Vallālasena, it is clear that 40 *unmāna* is smaller than an *āḍhavāpa*, since the grant refers to 7 *pāṭaka*, 9 *drōṇas* 1 *āḍhaka* (*āḍhavāpa*) 40 *unmānas* and 3 *kākas* (kākini).[124]

The lost Sunderban copper plate of Lakṣmaṇasena has been translated in different manners, by different authors. The grant consisted of a plot of land of a village called Maṇḍalagrāma, along with a homestead, measuring 3 *bhudrōṇa*, 1 *khādika*, 23 *unmāna* and 2⅓ *kākini* according to the standard of (*dvādaś-āṅgula adhika hastena, dvātrimśadhasta parimitomānena*) 32 cubits, a cubit equalling 12 *aṅgulas*. In this sense *unmāna* would be 32×32 cubits=1024 sq.yds=1/9 bigha (0.15 acre).[125] However, Dr D.C. Sircar has suggested that the first part of the inscription suggested a cubit of 36 *aṅgulas* (27 inches) and the second to the *nala* of 32 cubits.[126] Considering an *āḍhika* to be of 5 bighas, 45 *unmāna* would be 1 *āḍhavāpa*. All the same, this cannot be considered as conclusive, because the medical text *Caraka Samhita*[127] and *Sārangadhāra Samhita*[128] equates *unmānas* with *drōṇa*. If this evaluation is considered, *unmāna*, perhaps may be equal to a *drōnavāpa*. However, it will be safer to conclude that it is a bigger unit than *kākinī* but smaller than *ādhavāpa*.

Kākinī or kāka is another term common in the copper plates from Bengal.[129] Perhaps this term stands for *kāṇi* mentioned in the literature. W.W. Hunter in his "*A Statistical Account of Bengal*" refers to *kāṇi*, which is a little over an acre in the Dacca and Mymensingh districts of Bengal.[130] In Sandvip in the Noakhali district of South East Bengal, 16 *kāṇi* is a don (*drōṇa*) and a *kāṇi* is of 20 *gaṇḍas* or 80 *kadās*. Since 30 *kāṇis* are regarded as *pakhi* measure of land (3622 sq. cubits) in Faridpur, one *kāṇi* will be 120 sq. cubits (0.4 acre).[131] In Tamil speaking areas *kāṇi* is still in vogue which varies from 1 to 1.32 acres (0.4 to 0.6 hectares).

Gaṇḍā appears in the India office copper plates of Lakṣmaṇasena, where 1 *drōṇa*, 1 *āḍha*, 28 *gaṇḍas* minus 1 *kāka* was given as gift.[131] Dr. Sircar vaguely surmises that *gaṇḍa* may probably be a substitute for *udmāna*. It is 1/20th of a *kānī* according to him while according to Wilson it is 1/5 of a *kāṇi*. From the measures current in Sandvip in Noakhali district the following equations are available:

4 kadās	1 gaṇḍa
20 gaṇḍās	1 kāṇi
16 kāṇis	1 don (droṇa)[132]

According to this table one *gaṇḍā* would be 6 sq. cubits which is also current in Sylhet.

Karīsa occurs only in the Buddhist records. In *Suvaṇṇa-kakkata Jātaka* and *Sālikēdāra Jātaka*[134] farms of 1000 *karīsas* are mentioned. According to Childers, 1000 *karīsas* would be 8000 acres.[135] Rhys Davids has taken *karīsa* as the area of land on which a *karīsa* of seed can be sown.[136] Childers also states that it is a superficial measure of 4 *ammana*. The *ammana* was probably of 4 bushels.[137] According to this a *karīsa* would be 16 bushels or 9 to 10 maunds of grain. 9 to 10 maunds can be sown in an area of 10 to 11 acres. According to a scholar[138], the 1000 *karīsa* mentioned in the *Jātaka* would be 10,000 or 11,000 acres and that seems to be quite a large area. Probably the *Jātaka* records are associated with poetic exaggerations. In *Kalinga-Bodhi Jātaka* the term *rājakarīsa* is mentioned.[139] This perhaps may be a royal measure.

Vrihipītaka occurring in a Maitraka grant, literally means a plot of land, where the standard sized basketful of paddy could be sown.[140]

Tumu is another land measure, mentioned in a large number of inscriptions, generally in Andhra. According to Mallaṇa it comprises of 25 *kuntas* and according to Brown it is 1/20th of a *puṭṭi*. *Tumu* is also used as a measurement for weight. So, in the inscriptions when they are used as *iddumu cenu* (two tumus of land), *regaḍi muttumu* (three tumus of land), *paṇdumu cenu* (ten tumus of land)[64], etc., it probably represents the sowing capacity. In the Pakala inscriptions dated Saka 1242, it is recorded that in the reign of Mahāmandaleśwara Kākatīya Rudradeva Mahārāja, the komaṭis of Nellore gave wet land having the sowing capacity of 5 tumus.[140a] This further confirms the fact that this term in relation to area measure represents the sowing capacity. Some scholars doubt

that these terms may represent the yielding capacities of land rather than the sowing capacities.

Mūḍe mentioned in the Alupa[141] and Kadamba inscriptions[142], from South Kanara, may also refer to the land having a sowing capacity of a *mūde* or *mūḍaka* of corn.

Adda occurs as land measure in the inscriptions from Guntur[143], Mahbubnagar[144] and Khammamett[145] districts in Andhra Pradesh. *Adda* is a measurement for wet land, measured in terms of sowing capacity.

Khaṇḍika, *khaṇḍuga* or *khaṇḍuva* or *khaṇḍu* were generally units for dry land in Andhra and Karnāṭaka areas but it is not always rigid. It can also define the area of wet land; but only the areas will be different. It can be said to represent 6400 sq. yds. of dry land and 10,000 sq. yds. of wet land. It is also a unit of weight equivalent to *khaṇḍi* or *puṭṭi*. As a dry measure, it varies very much from region to region. For example it is 409,600 tolas in Belgaum, 13,440 tolas in Mysore and 128,000 tolas in Coorg.[146]

A copper plate from Nagamangala (777 A.D.) indicates, that Prithvi Kongaṇi Mahārāja Vijaya Skandadeva donated several *khaṇḍugas* of land for garden, house site and irrigation along with some waste land for a Jain temple.[147] The editor suggests that it refers to that much of a land needed for sowing several *khaṇḍugas* or *khaṇḍuga*, a khanduga being equal to 3 bushels of seeds. In another inscription belonging to the time of Kongaṇi II, Avinīta gave several *khaṇḍis* of land to a brāhmaṇ Devavarman.[148] In the Gaṇeśghad copper plates of Maitraka king Dhruvasena I (Gupta year 207) eight *khaṇḍas* of land measuring 300 *pādāvartas* and two cisterns in the village of Haryānka were donated to a brāhmaṇ Dhammila.[149] Hence one *khaṇḍa* would be 37½ *pādāvartas*. *Kha* which is found in a number of inscriptions, might be an abbreviation of *khaṇḍuka*.[150]

Kolaga is also a land measure occurring in the inscriptions from Karṇāṭaka[151] and Andhra.[152] This may represent the sowing capacity. *Solage*, *salage* and *sollage* occurring in the various Karṇāṭaka grants also refer to the same sowing capacity.[53]

Puṭṭi which occurs in Andhra inscriptions is of 500 *kuntas*.

Puṭṭi is also a weight and hence it could be the sowing capacity or even yielding capacity. As a weight it is a ton, according to Brown's Telugu dictionary. The sowable capacity of 1 *putti* of grain would be 80 acres by transplantation method and 40 acres by direct sowing. The former is known as *callakamu* and the latter is known as *udupu* in the West and East Godavari districts and *nareta* in Nellore district. Several inscriptions refer to *puṭṭi*, *puṭṭendu cenu* (one puṭṭi of land), *aidu-puṭla-cenu*, (five puṭṭis of land), *padi-puṭṭa cenu* (ten puṭṭis of land)[53], *pamdreṇḍu puṭṭa-cenu* (twelve puṭṭis of land)[154], etc. There seems to be different kinds of *puṭṭis* also and one such term is *gal-puṭṭi*.[155]

Bhūmi literally means a land. It is referred to in *Śatapatha Brāhmaṇa*, in relation to land gifts.[156]

This measure has been utilized earlier, in Vākāṭaka and Gupta inscriptions. In the Chammak copper plate inscriptions of Mahārāja Pravarasena II, the village of Cārmānaka was measured by 8000 *bhūmi* according to the royal measure.[157] In the Dudia plates of Pravarasena II, issued in his twenty-third regnal year, grants were made in the Arammi rajya, 25 *bhūmis* of land at Darbhamalaka in the Candrapura confluence were granted to Yakṣarāya and 60 *bhumis* at the village of Karmakara in the Hiraṇyapura bhoga to Kaliśarman.[158] From these records, the area which this term represented, could not be ascertained. But Dr. Mirashi, however, translated *bhūmi* as *nivartana*.

In certain places the term *bhūmi* clearly refers to the yielding capacity. In the Gauhati plates of Indrapāla, the *bhūmi* allotted is specified as land in which 4000 measures could be grown (*Chatuḥsahasrotpattika bhūmau*).[159] Similarly in the Nowgong copper plate of Balavarman, the land called Hensive, with a producing capacity of 4000 measures of rice (*dhānya-chatus-sahasrotpattimatī Hensive, abidhāna bhumiḥ*), was given as gift.[160] Two copper plate grants of Ratnapāla of Pragjyotiṣa (1st half of 11th century A.D.) refer to a price of land, each producing 2000 measures of rice (*dhānyadvisahasrotpattika bhūmau*).[161]

In the Cambā copper plate inscription of Somavarmadeva and Āsaṭadeva *bhū*, *bhūmi*, and *bhū maṣaka* occur as land

measures. The editor surmises *bhūmi* to be a superficial measure and *bhū* as ths shortened form for *bhūmi*. *Bhūmaṣaka* is regarded as one fourth of a *bhūmi*.[162] Certain inscriptions refer to *bhūmi* in the sense of a land as in the case of '*nilam*' in the South Indian inscriptions.

There are certain terms which does not come under any of the above categories, but were prevalent in local usage. The information available on these terms are given below.

Vāṭi or *vāṭika* generally means a garden, enclosure or fence. This term is very common in the inscriptions from Orissa. It is defined in *Mayamatam* as of 5120 *sq. daṇḍas*[163], the latter being 4 cubits each. According to this calculation a *vāṭi* will be 4.48 acres. According to Wilson's glossary, it is 20 *mānas*.

The terms *vāṭika*, *māna* and *guṇṭha* can be ascertained to a certain extent from the Kendupaṭna plates of Narasimha II (Śaka 1217). The land measuring 100 *vāṭikas* was granted to Bhīmeśvaravarman in four pieces. The first plot was in the village Vakalagrāma. The land measured 60 *vāṭikas* 7 *mānas* and 20 *guṇthas*, out of which cattle lands covered 26 *vāṭikas* 2 *mānas* and 15 *guṇṭhas*. Hence the area allotted was 34 *vāṭikas*, 5 *mānas* and 5 *guṇṭhas*. The second plot in Gadhaigrāma measured 40 *vātikas*, 17 *mānas* and 1 *guṇṭha*, of which the cattle track was 11 *vāṭikas*, 0 *mānas* 3 *guṇṭhas*. The remaining 29 *vāṭikas*, 17 *mānas* and 23 *guṇṭhas* were allotted. The third plot was in the village of Kalingagrāma measuring 10 *vāṭikas*, 17 *mānas* and 8 *guṇṭhas*. Of this the pasture land covered 1 *vātika*, 16 *mānas* and 23 *guṇṭhas*. The remaining 9 *vātika*, 0 *mānas* and 10 *guṇṭhas* were granted. The fourth plot measured 31 *vāṭikas*, 15 *mānas* and 6 *guṇṭhas*, out of which cattle track and pasture land covered 4 *vāṭikas*, 17 *mānas* and 19 *guṇṭhas*. Therefore, the land allotted was 26 *vāṭikas*, 17 *mānas* and 12 *guṇṭhas*. The total land granted is, therefore, as follows:

	vātikas	mānas	guṇṭhas
	34	5	5
	29	16	23
	9	0	10
	26	17	12
vātikas	100	0	0

Here, *māna* consisted of 25 *guṇṭhas* and 20 *mānas* make a *vāṭika*. Since the *māna* is now regarded as equal to an acre in Orissa a *vāṭi* must be 20 acres.

Guṇṭha or *guṇṭa* is a common land measure in the inscriptions from Andhra and Orissa[165]—this is considered as 1/25th of a *māna* at present. Hence, it can be considered as 2 acres. Generally it varies from 120 to 200 sq. yds. Till recently a *guṇṭha* is 1/40th of an acre in Karnāṭaka. People do not use fortieths when they divide a *guṇṭha*, but devide it into sixteenth of an *anna*. $8\frac{1}{4}'' \times 8\frac{1}{4}'' = 68\frac{1}{16}$ sq. ft. is an *anna* and 16 such *anna* is a *guṇṭha* (sq. ft. or 121 sq. yds.).

Till recently in Kairatnagar zamindari a *guṇṭha* is a chain of 60 country feet of unirrigated land and 56 country feet of irrigated land. The country foot is the length of the foot of the goddess, in the temple of Kampūlapāliyam, which is equal to $10\frac{1}{4}''$.[103]

Timpira is a rare term mentioned only in the inscriptions from Orissa. In a charter of Dharmarāja Mānabhita (695-730 A.D.) of Sailodhbhava family of Kengoḍa in Orissa, land was measured in *timpira*.[166]

Pratyāndaka occurs in a single inscription, from Tiḍguṇḍi, during the time Vikramāditya II (1083 A.D.). King Munja's ancestor Bhīma, was described as the lord of 4000 *pratyāndakas* (*Pratyandakaka chatusahasrādeśādhipati*).[167]

Kunta is a common term in the Andhra inscriptions and 12×12 sq. hastas according to *Sārasangraha gaṇita*. An inscription, dated Śaka 1140, states that one Vailama seṭṭi gave 200 *kuntas* of wet land to the god, Gaurīśvara Mahādeva.[168] Another record registers a gift of 13,000 *kuntas*, given by Rudra Perggade for the religious merit of Rudra Mahādeva.[169]

Maṭlu occurs as a measurement for waste land as well as garden land. The Pillamāri inscription of Śaka 1130 refers to 4 *maṭlus* of garden land, 2 *maṭlus* of waste land.[170]

Vīśa or *vīśamu* is referred in Taṇḍuvāyi inscription and is considered as two acres.[171]

Paṭṭu occuring in Kurichedụ inscription (Saka 1092)[171] and Timmasamudram inscription[173] cannot be identified.

Kuchchela occuring in the Andhra records is considered as 25 to 29 acres.[174]

Gorru is an unspecified land measure occurring in a few inscriptions.[175] At present at Guntur, *gorru* is equal to 3.167 acres. It varied from 5, 4, 4.6 and 1.1 acres in South Arcot district till very recently.

Baralu is a linear standard, measured with a pole of 12 yards. An inscription from Candalur refers to a gift of lands measured with a pole of 12 *baralu*.[176]

Pedda gadyamu is mentioned in the Mellacherumu inscription of Śaka 1233.[177] Pedda means big in Telugu and gadyamu, may have some connection with gajamu or yard.

Ceṭulu is a measure employed for measuring house-sites in Andhra.[178] It literally means an arm's length.

Mullu and *muḍlu* also occur in connection with house-sites. A Pālakol inscription refers to *mullu* in connection with gṛhakṣetra.[179] Another inscription also refers to *muḍlu* for a gṛhakṣetra.[180] Perhaps these terms may be the same as *mura* or *muralu*, which is equal to ½ yards, corresponding to Tamil *muḷam*.

Patikāḍu or *patuka* is another measure of land mentioned in the inscriptions from Andhra[181]. *Patuka* or *patikāḍu* in Telugu means ¼ of anything.

Khāris of land occurs in the Andhra inscription dated S.S. 1352. It is not clear, whether it refers to the sowing or the yielding capacity.[182]

Hāda (Sanskrit Pāda) mentioned in Kannaḍa records[49] is considered as ¼ of a nivartana.

Pātha is mentioned in the Timāna grant dated 1207 A.D. The Mehara King Jagadekamalla, perhaps a feudatory of Cālukya Bhīma II, made a gift of 55 *pāthas* of land in each of the two villages, Kambalanti and Pulasara.[183] According to Wilson and Dr. D.C. Sircar, it is equal to 240 sq. ft. and perhaps may be synonymous with *pāṭaka* of Bengal and *pāḍagam* of extreme south. It has already been seen that *pāṭaka* is a very big-land measure leading to several acres.

Pādāvarata can be interpreted in several ways. Etymologically the term suggests the measure by foot. It is one foot each way or 1 foot square. When the land survey was conducted in the time of Kulottunga Coḷa I, his foot measurement (Śrīpāda) was taken as the unit.[184] This may be the case

with the Maitrakas also, where the royal standard was perhaps taken into consideration. In one of the gifts of Maitraka king Dharasena II from Pālitana alongwith the other gifts the king gave sixteen *pādāvartas* as a gift. This is too small an area to be gifted and mentioned in a grant.[185] In another inscription of Dharasena II, three hundred and thirtyfive *pādāvartas* of cultivated land were given to a dīkṣita. The land was in five pieces, 120, 100, 90, 15 and 10 *pādāvartas*.[186] Ten *pādāvartas* would be a very small size to be cultivated. Perhaps this may be for a building site or even a well since it was an agricultural land. As in the case of the Roman concept of mile, the step rather than the foot might have also been taken into account.

Till recently, in some of the villages in South India, the foot measure of the Goddess of the local temple which is 10¼″ was taken into acconnt, while measuring land. Here it represents only the foot and not a step.

Pādāvarta has another interpretation also. The term *pāda* stands for ¼ of a circle or square or any thing. Hence, it may be taken as ¼ of a bigger unit.

Pāṣa may be the equivalent of rajju of Kauṭilya. During the reign of Bhīma II, Mahipāla gave 350 *pāśas* of land yielding 4 *khaṇḍikas* to one Mādhava.[187] Measuring by hempen rope was mentioned by Abul Fazl. The ancient Greeks used the cable of 61 ft (600 Greek feet). The rope measure of 32 yds. was in use in Tamiḻnāḍu till recently.

Kedāra or *keyār*, which was current till recently in Sylhet, can also be traced in the Penukoṇḍa plates of Mādhava, where a grant records 65 *kedāras* of land in Karmatuvakṣetra, which could be sown with 27 *khaṇḍukas* of seed (800 to thousand seers). *Kedāra* literally means a water-logged area. According to Padmanath Bhattacharya's table, a *kedāra* is 0.3 acre in Sylhet.[91] Nihar Ranjan Roy has given the following table which includes *kedāra*.

3 krānti	=1 kaḍā
4 kaḍā	=1 gaṇḍā
20 gaṇḍā	=1 paṇa
4 paṇa	=1 rekhā
4 rekhā	=1 yaṣṭi
7 yaṣṭi	=1 poā
4 poā	=1 kedāra or keyār (7/8 bigha)[189]

This table and the table of Padmanath Bhattacharya agree that 28 *yaṣṭis* make one *kedāra*. Whether the *kedāra* mentioned in the Penukonda inscription is also of the same area is not certain

Kāṇi is still in vogue in South India. Since as a fraction it is 1/80, Dr D.C. Sircar came to the conclusion that it is 1/80 of a *veli*. Actually the term "*kāṇi nilam*" refers to a tract of land. *Kāṇi* is mentioned in the ancient Tamiḻ works *Tolkāppiyam* and *Nālaḍiyār*.[190]

In some places *kāṇi* is 1/8th of a *veli*. This term varies from 0.75 to 1.5 acres. In certain Tamiḻ speaking areas, the land measure is an area in which a certain quantity of seed can be sown, but this is only an estimate. In North Arcot district 7½ Madras measures are required to sow a *kāṇi* of irrigated land and 36 Madras measures are required to sow a *kāṇi* of unirrigated land. The Madras measure is called *paḍi* and was used till recently in Madras bazars, having a stuck capacity of 62½ fluid ounces in terms of volume or about 110 tolas of weight of rice, but when heaped it will be about 122 tolas.

Kāṇi in E. Bengal is a little over an acre in the Dacca and Mymensing district. In the Faridpur district it is equal to 120 sq. cubits. In Sandvip, in the Noakhali district, *kāṇi* is equal to 1/6th of a *don* (*drōṇa*) or equal to 20 *gaṇḍās* or 80 *kaḍās*.[180] In Oriya it is only a hand's breadth.

The term *kākaṇika* measuring 256 yds in *Mayamatam* [163] does not seem to have any connection with *kaṇi*.

Muntrigai or *mundiri* is actually the fraction 1/320. As a land measure it is 1/320th of a *veli*. According to mathematical works it is 1/320 of any measure. *Mundiri* occurs in the ancient Tamiḻ works *Tolkāppiyam* and *Nālaḍiyār*.[190]

Sṛi, which literally means a field, occurs as a land measure in the inscription from Tamiḻnāḍu and Kerala.[191] It is 276×276 sq. ft. or 1.75 acres (0.7 hectares) at present.

Kuḷi is of 576 sq. ft. and 100 *kuḷis* make a *mā* and 20 *mās* a *veli*. Literally *kuḷi* means a pit, *ma* means 1/20th and *veli* a fence.

It may be noticed from all these area measures of ancient India described above, most of these area measures were used

generally for making gifts of land and later on for cadastral surveys. The same terms appear to denote different regions even in the same period and also appear to be different in the same region from period to period, just as in the case of the linear measures in ancient India.

In different regions, the approach towards measuring out the lands appeared to have been different. The use of *daṇḍas* of definite *hastas* appear to be in vogue in many regions from very ancient times, even though the length of the *daṇḍa* was not uniform at all places. The area measures namely *nivartana* and *gocarman*, though used extensively in most of the regions, it is really very difficult to say exactly what extent of area they really represented. Probably, at each place a local standard *daṇḍa* and a local definition of the number of *daṇḍa* squares were adopted purely as local standards in relation to these area measures.

Certain type of area measures were purely regional. The terms *mattar*, *marutu*, *kamba*, etc., were used mainly in Andhra and Karnāṭaka regions, while the terms *paṭṭi*, *kuḷi*, *mā*, *veli*, *kāṇi*, etc., were used in the far South.

For agricultural lands the plough measure like *hala* appears to have been used more extensively. The plough measure concept appears to be in vogue even in other ancient civilizations also, as seen from the present day furlong, which arose out of the furrow-length.

On the Eastern regions, the area measures associated with the quantity of seed sown or based on the yields, were used more extensively than in the other regions.

Area measures based on sowing capacity was used in other ancient civilizations also. For example the Palestinian jugon (which is equal to 13 Roman jugera) is also called korean, because the land required a kor of seed for sowing. Jugon is approximately 8.1 acres (about 3.2 hectares).[192]

Thus on the whole the area measures of ancient India appears to have been based purely on local standards and usage without any all India standardization, just as in the case of the linear measures of those times. Many of these measures have been in use till very recently in many areas.

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184. *MER*, 1912, No. 440.
185. *EI*, XI, p. 104.
186. *EI*, XXII, p. 114.
187. *IA*, XVIII, p. 112.
188. *Ain-i-Akbari*, Vol. II, p. 417.
189. *Proceedings of the Asiatic Society of Bengal*, Vol. VIII, p. 188.
190. "Kāṇiye mundririgai" *Tolkāppiyam* Eḷuthadikaram-164. "Mundiri merkāṇi mikuvadel" *Nālaḍiyār 364*.
191. *EI*, XX, p. 46.
192. *Historical metrology*, p. 96.

4

Volume measures of Ancient India

THE earliest concepts of volume measures must have arisen in India in relation to giving offerings at Vedic rites and also in giving alms and gifts of grains and valuables, as well as, for rough measures in cooking and other activities. *Muṣṭi*, which is a handful, would have been the earliest and the easily conceivable volume measure for such purposes. Both the palms cupped together either to receive or to give grains, food, etc., can also be a very early practice. Thus, *muṣṭi* (palmful) and *añjali* (the double palmful) must have been the basis for conceiving larger volume measures in ancient India. In the Vedic literature, the volume measures like *añjali* and *prasṛti* are mentioned. In the subsequent periods, many volume measures came in to use on regional basis, without any standardization of general nature. Some of the terms were the same, but the actual volume they represented differed from area to area and also from period to period even in the same area, just as in the case of linear measures and area measures described in the earlier chapters. In this chapter, the various volume measures in use in ancient India are mentioned in the order of increasing volumes and in each case the references are given in the chronological order of the period in which they were in use. Efforts were also put in to indicate the volume equivalence they represented in relation to each reference.

Before going into the details of each measure, it would be worthwhile to point out briefly a peculiarity in the use of volume measures, such as *kuḍava, prastha, āḍhaka, drōṇa*, etc., as weight measures also in ancient India. An example of a similar nature can be noted in the modern term ounce. The same term ounce, when it is used as a volume measure it is nearly 28.5 cc, and as a weight measure it is 28.5 gm., taking into consideration the fact that 1 cc of water at 4°C is equal to 1 gm weight. In a similar way in the past in India, the volume and weight measures were primarily used for the measuring of grains, using the hollow volume measuring vessels. These were equated with the weight of that amount of grain which that vessel can deliver. Here again two variations are possible. Since the grain can be measured out in a heaped measure, the weight will be more than the stuck capacity of the same vessel. These two variations, along with the confusion, relating to whether one is talking about volume or weight in a given reference, have created great difficulty in equating the values given by different authors, at different times and at different places in ancient India. Efforts have been made in this study, not only to present the information as available in the inscriptions and literature, but also finally to present them in a tabular form trying to bring out their possible equivalents.

It will also be relevant to mention another aspect here. Sārngadhara[2a] in his medical treatise had to use very small weights and volume measures using seeds of various types (e.g. marichi, mustard, sesame, barley, etc.) and relate them to the terms like *āḍhaka*, etc., in his table relating to weights and volume of drugs and materials used for making medicines. These will also be referred to in this study.

Muṣṭi, which represents the closed fistful is the oldest volume measure mentioned in Vedic literature. A fist size will vary considerably from individual to individual. A *muṣṭi* of paddy is found to be approximately 60 cc on an average. 60 cc of paddy approximately weighs 32 gms. *Muṣṭi* would have been the most convenient form of measure to give alms, gifts of grains, etc., in ancient India. *Piḍi* is the counterpart of *muṣṭi* in Dravidian languages. Mahāvīra's *ṣodaśika* might also be a *muṣṭi*. A *muṣṭi* is said to be equivalent of *pala* by many authors.

Prasṛti designates, primarily, the hollowed hand stretched out to receive what is offered. It occurs first in *Śatapatha Brāhmaṇa* as a measure of capacity meaning a handful. Two *palas* or two *muṣṭis* constituted a *prasṛti* according to the Purāṇas.[3]

Añjali means two handfuls joined together; that is double of *prasṛti*. In the Purāṇas and mathematical works[4], this is also termed as *kuḍava* or *seṭika*. *Kuḍava* according to Bhāskaracārya is a vessel made of earth or similar material, which is in the shape of a cube measuring $3\frac{1}{2}$ *aṅgulas* in every dimension. Since Bhāskara considers 8 *yavas* for an *aṅgula*, his *aṅgula* can be equated with an inch. Thus the volume of *kuḍava* would be ($42\frac{7}{8}$ c. *aṅgulas* or 550 cc approximately). *Kuḍava* according to the medical text *Sārangadhara samhitā*[5] is a vessel made of mud, wood or bamboo having 4 *aṅgulas* diameter and 4 *aṅgulas* in height.

मृद्वृक्षवेणुलोहादेर्भाण्डं यच्चतुरंगुलम् ।।
विस्तीर्णं च तथोच्चं च तन्मानं कुडवं वदेत् ।

Considering *aṅgula* as 6 *yava* pramāṇa, which is equal to $\frac{3}{4}''$, a *kuḍava* would be about 330 cc. This is in relation to *Magadhamāna*. Sārangadhara refers to a *Kalingamāna* also, which is slightly different from *Magadhamāna*. The term *kuṭaka* appearing as a measure for salt in Harṣa stone inscription[6] may probably denote a *kuḍava*. In *Avadānaśataka*, *kudava* is termed as *kavaḍa*[7]. Modern *chāvdo* of Gujarat seem to be the same as *kuḍava*.

Kunchi occurs in *Varāhapurāṇa*[8] consisting of 4 *prasṛti* or 8 *muṣṭis*. This may be synonymous with *mānika* of the medical texts.

Prastha is a common term in Purāṇas and mathematical works measuring 8 *prāsṛtis*. A vessel of 5 *aṅgulas* in height and 4 *aṅgulas* in diameter (पचांगुलावटं पात्रं चतुरंगुलं विस्तृतम), is a *prastha* according to Śukra.[9] Since according to Śukra[10] an *aṅgula* is of 5 *yavapramāṇa*, which is equal to 0.6 inch, his vessel measuring a *prastha* will be equal to about 37.7 c. inches (514.58 cc) if it is cylindrical and if it is cuboidal ($2''\times2''\times3''$)

then it would be 12 c. inches (196.65 cc) in capacity. According to *Varāhapūraṇa*, a *prastha*, which is also termed as *puṣkala*, is equal to 64 *muṣṭis*, which will be 4 times larger than in other references. In *Kaṇakkusāram*[11], a text book in Malayālam, *prastha* is considered as being equal to an *idangaḷi*, which is approximately 2 litres.

A solitary inscription from Mathura refers to a *prastha* of salt.[12]

Taking into consideration the fact, that a *muṣṭi* is approximately 60 cc and since a *prastha* is equal to 8 *prasṛtis* or 16 *muṣṭis*, a *prastha* can be just short of a litre in volume and this fits in with that of *Śukranīti*. According to Sārngadhara, dry and liquid measures are one and the same upto *kuḍava*. From *prastha* onwards liquids are measured by a standard, double that of dry materials.[18]

प्रस्थादिमानमारम्य द्विगुणं तद्द्रवार्द्रयो: ।
मानं तथा तुलायाश्च द्विगुणं न क्वचित्स्मृतम् । 1:35

Aḍhaka (ālhaka-Pāli) is used as a measure of weight as well as capacity. It is generally accepted as ¼ of a *drōṇa* of 4 *prasthas*. However, Śukra[9] differs slightly, since he states that 5 *prasthas* make an *āḍhaka*.

Varāhamihira distinguishes two types of *āḍhakas*, one for measuring water (water *āḍhaka*) and another for measuring other materials (ordinary *āḍhaka*). The water *āḍhaka* of 50 *palas* was referred to by him for measuring rainwater. He uses this water *āḍhaka* for selecting the suitable building sites as follows. According to him, the earth dug out of a pit in the house site, when filled into the water *āḍhaka*, should weigh 64 *palas*, if the site is suitable for building construction. That obviously indicates that the soil should have a density of at least 1.28 for building construction. Lighter weight or loose soils would be unsuitable. Varāhamihira states that these measures are according to *Magadhamāna*.[14] This concept of an *āḍhaka* having 50 *palas*, is also confirmed by Kauṭilya[15], who considers the state revenue measure of *drōṇa*, as being equal to 200 *palas*, a *drōṇa* being equal to 4 *āḍhakas*.

Monier Williams equates an *āḍhaka* with 7 lbs. and 11 ounces, which does not fit in with the above calculations, but

appears to be more in keeping with Sārangadhara and Caraka[16] who consider an *āḍhaka* to be equal to 128 *palas*. Dr. D.C. Sircar describing the Bengali measures based on mediaeval Bengali measures described by the medieval Bengali writers on Smriti, such as Kullūkabaṭṭa, Raghunandana, and Pañcānana Tarkaratna[17] gives the following table of weight measures.

8 *muṣṭi* (handful)	=*kuñchi*
8 *kuñchi* (64 handful)	=*puṣkala*
4 *puṣkala* (256 ")	=*āḍhaka*
4 *āḍhakā* (1024 ")	=*drōṇa*
8 *drōṇa* (8190 ")	=*kulya*[18]

Here along with Śrīpati[4], these authors appear to consider an *āḍhaka* to be equal to 256 *palas* or *muṣṭis*.[19] The various tables of measures according to different authors are given at the end of this chapter. This higher value for the Bengali measures is in keeping with the Bengali compilation of *Śabdakalpadrumā* (quoted by Dr D.C. Sircar), where a Bengali seer was double the kacha seer used in Western India. Thus the same term *āḍhaka* also appears to have been used to denote different volume and weights in different parts of India at various times.

Āḍhaka and *prastha* are mentioned in the Mathura inscriptions[12] of Haviṣka, in relation to an endowment for feeding the brāhmans. In the Bijapur inscription[20] of Rāṣṭrakūṭa Dhāvala, *āḍhaka* is used as a measure for wheat and barley. In the Parasurāmésvara inscription[21] from Bhubaneśwar, grain was measured by *āḍhaka*.

Drōṇa literally means a trough, vessel or bucket. In *Ṛgveda*[22], it specifically designate in plural for vessels holding *soma* juice. It is uniformly accepted as a measure constituting 4 *āḍhakas* or 128 *prasṛtis*.

From the *Arthaśāstra* of Kauṭilya[15], it appears there were four kinds of *drōṇas*, namely harem measure (16½ palas), servants measures (175 palas), public measure (187½ palas) and king's measure (200 palas). There is an uniform difference of 12½ *palas* between them. According to medicinal texts[6], there is also a fifth variety measuring 256 *palas*.

In the Chauhan incsriptions[23] mention is made of *kumāra drōṇa* and *drōṇi*. According to Sārangadhara[24] *drōṇi* was a bigger unit than *drōṇa* and was equal to 4 *drōṇas*. In the

Paṭanārāyaṇa inscription[25] the term *drōṇakhāri* occurs. This might be taken as comprising two words *drōṇa* and *khāri*. The terms *drōṇa* and *drōṇavāpa* as land measures occur mostly in Gupta inscriptions[26], which refer to the sowing capacity of the land.

According to Sārangadhara[27], *kalaśa, nalva, ghaṭa, armana* and *unmāna* are all synonymous with *drōṇa*.

Khāri in *Ṛgveda*[28] refers to a measure for Soma juice. This term frequently occurs in inscriptions and literature. 16 *drōṇas* make one *khāri*, according to *Arthaśāstra*[15], Purāṇas[3] and mathematical works.[4] Śukra differs in stating that 20 *armanas* (120 *āḍhaka*) as a *khārika*. From *Līlāvati* it is clear that *khāri* or *khārika* of Magadha should be a cube measured by one cubit. A vessel measured by a cubit in every dimension is a *ghanahasta*, which in Magadha is called *khārika*. "It should be made of twelve corners or angles formed by surfaces". (Since the *hasta* mentioned by Bhāskara is 24″ the volume would be 8 c. ft. (i.e., 0.25 c c).[29] *Khāri* according to medical texts and *Abhidānappadīpika*[30] is of 4 *drōṇas*, while according to Jivaśarman[31] it is equal to 20 *drōṇas*. *Khāri* as a measure for grains is mentioned in Kalhaṇa's *Rājataraṅgini*[32]. Perhaps, the present day *khārbar* (ass load) might have derived from *khāri*.

In a grant of Somavarmadeva and Āsatadeva[32], *khāri* occurs as a measure for grain. *Doṇakāri*, mentioned in the Paṭanārāyaṇa inscription[24] is explained by the editor as the same as the corresponding Marwari word *doli*. Otherwise the expression may be taken as comprising *drōṇa* and *khāri*. In an inscription of Subhikṣarājadeva[34] from Pāṇḍukeśvar, *khārivāpa* is mentioned as a land measure. It seems to refer to an area of land, where one *khāri* of seed can be sown.

According to Abul Fazl[35] and Moorecraft[36] a *khāri* is equal to 1960 *palas*. Considering a *pala* to be $3\frac{3}{4}$ tolas, *khāri* corresponds to 177 129/175 lbs. Wilson considers *khāri* as equal to 3 bushels and *kharwar* as 700 to 850 lbs.[37]

Māṇi or māṇika seems to be another controversial unit of measure. *Māṇika* consists of 2 *kuḍavas* or a *prastha* according to the medical texts and *Ain-i-Akbari*[35] whereas it is of 4 *drōṇas* or 64 *prasthas* according to Mahāvīra.[5] The difference is too wide in the ratio of 1:128.

While describing the equitable distribution of food, *Divyavādāna*[33] mention one *māṇika* per unit (*eka māṇika bhaktasyavasiṣta*). In *Abhidānappadīpika*[30] *māṇika* and *drōṇa* are considered as synonpmous.

In the Partāpgarh inscription[39], the word, *māṇi* is used as a measure, for seed, while in the Bhinmāl stone inscription[40] the term *māṇa* is mentioned.

The term *māṇika* occurs mostly in the inscriptions from Andhra. Salt, milk, ghee and oil were measured by this unit. There seem to be several types of *māṇikas*, namely, *Sanyambadi-māṇika*[41], *Deva-māṇika*[42] and *Nandi-māṇika*[43]. *Sanyambadi-māṇika* might be the *māṇika* used at a place known as Sanyambadu. *Nandi māṇika* might have had the figure of nandi on it. *Mummuḍi Bhīma māṇika*[44] was named after the king of that name. In Andhra records *māṇa* and *māṇika* seem to be synonymous. Whether *māṇi* or *māṇika* has any connection with *māṇa* as a measure of weight is not clear.

Pravartika is mentioned only by Mahāvīracārya, comprising of 5 *khāris*. Since the term *pravartika* stands for something round, *pravartika* may be a cylindrical vessel. *Pravartavāpa*, as a land measure meaning the sowing capacity of the land occurs in the inscriptions from East Bengal[45] and it is a conjecture that it measures half of a *kulyavāpa*. In the Alagum inscription of Anantavarman (regnal year 62)[46], several *pravartas* of paddy were given as gift. Dr. Sircar points out that pauti measuring 10 maunds in Orissa may perhaps be the same as *pravarta*.

Kumbha occurs mostly in literature. There is no unanimity in the quantity it represents. 20 *drōṇas* make one *kumbha* according to Kauṭilya and Purāṇas while 15 *drōṇas* make one *kumbha* according to Śrīdhara[47] and Śrīpati.[4] Mahāvīra considers *kumbha* as constituting of 400 *drōṇas*. In *Anuyogadvāra sūtra*[48], three types of *kumbhas*, *jaghanya* measuring 15 *drōṇas*, *madhyama* measuring 20 *drōṇas* and *uttama*, measuring 25 *drōṇas* are classified. According to Bhaviṣyapurāṇa and Sārangadhara 2 *drōṇas* make a *kumbha*, which is otherwise termed as *sūrpa*.

Ammanam is a peculiar measure consisting of 11 *drōṇas* according to *Abhidānappadipika*[30]. Childers considers this as

a superficial measure equal to 4 *karīsas*.[49] It is synonymous with *drōṇa* according to Sārangadhara. Śukra mentions the *māna* as being equivalent to 8 *āḍhakas*. The measure *ambanam* referred to in the Sangam literature *Padirṛuppattu*[47a], may be similar to this. The editor considers *ambanam* as equal to a *marakkāl*, The term *ammanam* in Ceylon stands for a measure of 46.08 gallons, which is a far bigger measure than *ambanam*.

Kalaśa is synonymous with *drōṇa* according to Sāranga-dhara.[5] In Śukra's *Nītisāra*[50], *kalaśa* is used in the sense of a pitcher. In certain areas in South India, till recently *kuḍam* and *combu*, meaning pitcher were used for measuring oil. Al-beruni[51] equates *kalaśa* with *Khvarizmain ghur*.

In the Janvara inscriptions[52] of Gajasinghadeva and Kelhaṇdeva (V.S. 1218) and in Bhinmāl stone inscription of Udayasimhadeva (V.S. 1306)[53], *kalaśa* was mentioned as a measure for ghee, while in the Sanchor stone inscription[53a] *muga* (*mudga*) was measured by *kalaśa*.

The measure *kalasi* equivalent to 16 maunds was current till recently in Gujarat. For measuring milk, however, a *kalaśa* of 5 seers was used.

Vāha is the biggest cubic measure mentioned in the tables given in the books of mathematics and law. 200 *drōṇas* make one *vāha* according to Śrīdhara[47], Śrīpati[4] and Kauṭilya[15], while Mahāvīra considers 320 *drōṇas* as one *vāha*. Sāranga-dhara[5] refers to a *vāhi* constituting 4 *drōṇas*, whereas according to Caraka[16], *vāha* is 128 *drōṇas*. For *vāha* Childers gives the meaning of a cart load, measuring 20 *khāris* or 80 *drōṇas*. With so much of variations, it is difficult to form any conclu-sion, excepting to state that *vāha* represents a very large measuring.

In Gujarat *galli* is a bullock cart load and this was equal to 30 maunds (600 kg). In the Telugu *bamḍi* means a cart. *Bamḍi*, *bamḍi peru*, *bamdi kaṭṭu* stand for cart loads. It is possible that a bullock cart had a quantity of merchandise and this quantity might have been considered as a definite unit for purpose of calculations. Generally articles like cotton, betel leaves, etc., seem to have been measured by the above men-tioned terms.

Ghaṭa or *ghaṭika* literally means a pot. Kauṭilya[15] refers to

a *ghaṭika* equivalent to a quarter of a *waraka*, the latter being 84 *kuḍumbhas* in case of butter and 64 *kuḍumbhas* in case of oil. A *kuḍumbha* is synonymous with *kuḍava* or *ghaṭa* accor-ding to Sārangadhara[13] and is equivalent to a *drōṅa*. *Ghaṭa* or *ghaṭika* might be a pot shaped vessel for measuring.

The term *ghaṭaka* occurs in the Mathura inscription of Haviśka.[1?] Rajor record[54] refers to a levy of 2 *pālikas* on every *ghaṭaka-kupaka* of clarified butter and oil. In the Siyodoni records[55], a tax of a *ghaṭika pala* of milk from every iron pan of confectionaries is mentioned. *Ghaṭaka* as a capacity measure occurs in the Bakṣāli manuscript[55a] also.

Gōni literally means a sack and its Dravidian counterpart is *kōni*. Sārangadhara[5] considers *vāhi*, *drōṇi* and *gōṇi* as synonymous, measuring 4 *drōṇas*, while Caraka[16] considers *gōṇi* as synonymous with *khāri* and *bhāra* which also measures 4 *drōṇas*.

The term *gōṇi prasṛti*, mentioned in the Mathura praśasti[56] of the reign of Vijayapāla, is mentioned by Colebrook[57] as a combination of *gōṇi* meaning a large measure equal to 4 *khāris* and *prasṛti* meaning a handful equal to 2 *palas*. In the Dubhund stone inscription[58] of Kachchapaghaṭa Vikrama simha, (V.S. 1145) a tax of one *vimśopaka* was laid on each *gōṇi*. A land with a sowing capacity of 4 *gōṇis* of wheat is also mentioned.[58]

At present *guṇa* in Gujarat is equivalent to 5 maunds or a quintal, which is almost the same in South India, but is termed as *kōṇi*.

Pāli, *pālika*, *pāila*, *pāyali* are terms which occur mostly in inscriptions and rarely in literature. These terms are used in measuring oil and ghee. In Rajor inscription[54], Partāpgarh inscription[39], Arthuna inscription[59], Nadlai stone inscription (V.S. 1189)[60] of Rāyapāla and Vāillabhaṭṭasvāmin temple insc-ription[61], the term *pālika* occurs; while in the Mathura praśasti of the reign of Vijayapāla[56] and Anavāḍa stone inscription[61a] of Sārangadeva the term *pāli* is used for measuring oil and ghee. In Junagadh inscription[62] of Sāmantasimha, Sanchor stone inscription[53a] of Pratāpasimha, in two of the Nadlai stone inscriptions[64] of Rāyapala (V.S. 1202 and 1203), the term *pāila* occurs. Perhaps all these terms may be synonymous. Opinions

differ about this measure. Dr. Bhandarkar on local enquiries at Godwad came across the following table:

4 pāila	=	pāyali
5 pāyali	=	māna
4 māna	=	sei
2 sei	=	man

In the Gaṇitasāra of Śrīdhara a different table is given:

4 pāvala	=	pāli
4 pāli	=	māna
4 māna	=	sei
3 sei	=	padaka
4 padaka	=	hāri
4 hāri	=	māni

From this table Dr. Sandesara[47] concludes that *pāila* or *pāili* is equal to 4 lbs.

The word *pāilām* occurs on the Sunak grant of the Cālukya king Karṇa I, which was identified by Buhler as equal to modern *pāyali* (4 seers or 2 kg). J.J. Modi[66] holds that *pāilām* is the same as *pallu* or *pallo* of Gujarat representing 6½ maunds. Padmanath Bhattacharya[67] gives a different table according to certain quarters in Sylhet:

7½ seers (paddy)	—	pūra
16 pura	—	bhuta
16 bhuta	—	pāila

Unlike in Gujarat, where seer seems to weigh 1.2 lbs, the seer in Sylhet is about 2 lbs. Hence *pāila* would be 16 maunds. Perhaps this may be like the Gujarati term *paḷo* meaning a large vertical cylindrical container of earthen or bamboo chips for storing corn.

A peep into Sanchor inscription[53a] proves, that *pāila* is a smaller measure than a maund. Here it is stated that Kamalādevi, queen of Pratāpasimha renovated the temple of Vaseśvara. For the maintenance of the temple a gift was made of a field as well as two *pāilis* on every *mān* of each commodity from the custom house.

In the Nadlai stone inscription[60] of Rāyapāla (V.S. 1200), rauta Rājadeva made a grant consisting of one *vimśopaka* coin from the value of the *pāilas* accruing to him and two *pālikas* from the *palas* of oil due to him from every *ghaṇaka* or oil

mill. In this text it is clear, that *pāila* and *pālika* are different and since *vimśopaka* itself is not of very high denomination, both *pāila* and *pālika* might not be very big units.

Pāli in Gujarati stands for a big ladle or spoon. G.H. Ojha's[39] conclusion that *pālika* is the same as *pala* comprising 6 tolas (69.98 gm) is nearer to this. According to Wilson[68] a *pāli* of gram is equal to 5 to 8 seers and *pāvali* 3½ seers. In the present Mahārāṣtra state, the term *pāyali* constitutes ¼ of a maund. *Pāili* in Gujarat is 1/440 of a *kalasi*, the latter being 16 maunds (5.97 quintal). Hence the *pāili* in Gujarat comes to about 1.3 kg. The term *pāyali* generally stands for a quarter and *pavāli* a cup or cylindrical vessel. It is not out of place to mention that in Chinese, *pāilo* is a drinking cup of about 500 gms. *Pāili* in Karṇāṭaka is 2.332 kg. From the above facts *pāli, pālika, payali and pāili* are supposed to be different terms measuring differently. At present the different terms are used as follow:

1. pāyali	¼ or 4 seers
2. pavāli	cup
3. pāli	big ladle or spoon
4. pālo	a large vertical cylindrical container for storing.

There are certain measures which are found only in South Indian literature and inscriptions. In the Tirumukkūdal inscription[69] of Vīrarājendra, most of the following measures found in Tamilnāḍu are mentioned.[50] They are *śéviḍu, āḻakku, uḻakku, uri, nāḻi. kuruni, padakku, tūṇi* and *kalam*, and they were not only current in the mediaeval times in South India, but also continued till recently with slight variations. The following table was given by Dr. Atleker[70] which was in vogue till recently:

5 śéviḍu	=	āḻākku (220 cc)
2 āḻākku	=	uḻakku (400 cc)
2 uḻakku	=	uri (800 cc)
2 uri	=	nāḻi or paḍi (1.6 litre)
8 nāḻi	=	marakkāl (12.8 litre) or kuruṇi
2 kuruṇi	=	padakku (25.6 litre)
2 padakku	=	tūṇi (51.2 litre)
3 tūṇi	=	kalam (152.6 litre)

(The figures in bracket were calculated by the author as stuck capacity).

Śéviḍu is the smallest measure of capacity mentioned in the inscriptions from South India. Perhaps *śéviḍu* might have been derived from the Sanskrit word *séṭika*. *Śéviḍu* might have been used as a measure of weight as well as capacity, since in an inscription of Nṛpatunga[71], kāyam (asafoetida) and ghee were measured in *śéviḍu*.

Āḷākku which is a measure for fluid as well as grains is 1/8 of a Madras measure till recently and was a common term in South Indian inscriptions. It is about 200 cc in volume. *Āḷākku* may be a derivation from the Tamiḻ word, '*aḷavu*' meaning a measure.

Uḷakku which is one fourth of a Madras measure till recently was also common in South Indian inscription measuring 400 cc.

There were several types of *uḷakku*. *Uḷakku* measured by *Aruḷmoḷidevan nāḷi* was current in the time of Rajendracoḷa in Kālahasti.[72] In Vedāraṇyam itself there were several measures. *Uḷakku* measured by the measure of Tirumaraikkāḍan[73] was popular. Tirumaraikkaḍu is the Tamiḻ translation for Vedāraṇyam. *Vedavananāyakan measure*[74] most probably might be the same and perhaps both may be temple measures. During the time of Kulottunga Coḷa III (1207 A.D,) an *uḷakku* of ghee measured by *Karuṇākaran nāḷi*[75] was gifted to the deity Tirumaraikkadu Uḍayan. During the time of the same king in 1181 and 1182 A.D., the *uḷakku* was also measured by *Vedavananāyakan nāḷi*[73]. During the time of Rājarāja I (1000 A.D.) in Vedāraṇyam an *uḷākku* was measured by *kāṇa nāḷi*.[76] *Viḍelviduga uḷakku*[71] mentioned in the Pallava inscriptions might be the measure current at that period.

Uri, which frequently appears in the South Indian inscriptions consists of 4 *āḷākkus*. There seems to be different *uris* also. *Pirudu māṇikka uri*[71] of Pallava records might refer to the standard of Nṛpatunga's queen. *Uri* has a stuck capacity of 800 cc and a heaped capacity of 850 cc.

Nāḷi may be a derivation from *nala*, meaning a hollow stalk, generally of bamboo. The *nāḷi* measure is shaped like a stalk of a bamboo. As a cubic measure, in almost all the

inscriptions belonging to the kings of South India this term is of frequent occurrence.

Several types of *nāḷis* occur in the inscriptions. *Ādavallān nāḷi* must be referring to the measure at Cidambaram.[77] *Aruḷmoḷidevan nāḷi*, suggests the standard of Parakesari Rajendra Coḷa I, while *Rājakesari nāḷi*, the standard of Rājarāja. *Aruḷmoḷidevan nāḷi* was smaller than *Rājakesari nāḷi*. $1\frac{3}{8}$ of *Aruḷmoḷidevan nāḷi* would measure 1 *nāḷi* of Rājakesari,, as understood by the Tirumukkūḍal inscription of Vīrarājendra.[69] In Vedāraṇyam, during the time of Rājarāja I (10th century A.D.) *kāṇa nāḷi*, *Karuṇākaran nāḷi*[78] are mentioned. *Vedavana nāyakan nāḷi*[80] and *Tirumaraikkāḍan nāḷi*[81] mentioned on the inscriptions from Vedāraṇyam perhaps may be the temple measures. As has already been stated, Tirumaraikkāḍu is the Tamiḻ equivalent for the Sanskrit name Vedāraṇyam. An inscription[82] from Tiruvarūr Thyagarājaswāmy temple, refers to *puṟṟidangoṇḍān nāḷi* equal to a *tuḍai uḷakku*. *Kāṇa nāḷi* was considered as half of *Parakesari nāḷi*.[83] In the Pandyan inscriptions *pilaya nāḷi*, *mānaya nāḷi*, *nālva nāḷi*[84] *Nārāyaṇa nāḷi*[85] and *karu nāḷi* occur[86]. A Ganga inscription from Kanchipuram refers to *Ariyenavalla nāḷi*.[87] *Pañcavāra nāḷi*[88] is the measure decided by Pañcavāra committee.

Generally a *nāḷi* is $\frac{1}{4}$ of a measure and is also known as *paḍi*. Madras measure (padi), when heaped, weighs 132 tolas and has a stuck capacity of 120 tolas or $62\frac{1}{2}$ fluid ounces (1.6 litres). In Madurai, Cidambaram and other areas, half of this is considered as the *paḍi*. Hence, *nāḷi*, in and around Madras must be double of other areas in the South. In certain areas *nāḷi* and *paḍi* are synonymous.

Idangaḷi, *edangaḷi* or *yedangaḷi*[89] is a term found only in Kerala inscription. It is a cylindrical measure $2\frac{5}{8}''$ high and $6\frac{1}{2}''$ in diameter or 85 cubic inches (1328 cc) in capacity. It is said to hold 57,600 grains of *kalama nella*, a kind of paddy[90].

Marakkāl consists of 8 Madras *paḍis*. It was formerly considered as a measure of 750 c. inches, but later on fixed as 800 c. inches according to Wilson.[91] Princep[91]*a*, however, considered a *marakkāl* to be equal to 27 lbs, 2 oz, 2 dr of water or $2\frac{3}{4}$ Imperial gallons. The standard as fixed in 1846 makes a *marakkāl* equal to 28 lbs, 12 oz, 13 dr, 22 gr or $2\frac{9}{10}$

Imperial gallons.[28] *Makrakkāl* also seems to have differed in different areas in the past also. *Marakkāl* measured by *Ādavallān* and *Rājakesari* measures were current in and around Tanjore area. *Marakkāl* measured by *Périḻamai* measure in South Arcot district must be larger than the ordinary *marakkāl*, since it was equivalent to 10 and not 8 *nāḻis*. In South Arcot district another *marakkāl*, measured by the *Mādévi* (corrupt for Mahādevi) measure also occurs. At Aṇṇāmalai, *marakkāl* was fixed by *Annama* measure and at Takkolam by *Kavaramoḻi* measure.[70] *Uchchilninna Nārāyaṇamarakkāl* was used in Tirupati.[92] It may be noted that the *marakkāl* is bound to differ with different *nāḻi* measures. That *Kāṇa nāḻi* was half of *Parakesari nāḻi* can be ascertained from 11th century inscription from Pirimiyam.[83] When *marakkāl* is measured with *kāṇa nāḻi*, it would be half of the *marakkāl* measure by *Parakeśari nāḻi*. *Panchavāra marakkāl* was less than ordinary *marakkāl* by an *uri* (i.e. *Panchavāra marakkāl* was measured as 7 *nāḻi* and a *uri* by *Rājakesari* measure) *Rājakesari marakkāl* measured 8 *nāḻis* by *Rājakesari nāḻi*.[93]

Though the measure *marakkāl* was in usage generally in South, it differed in capacity in each district. In Sholinghur and Ārṇi, *marakkāl* was 2½ heaped *paḍis* while in Tirupati as in Madras it was 8 heaped *paḍis* and in Vellore 4 heaped *paḍis*. Hence this measure seems to have variations associated with the local usage.

Padakku mentioned often as a corn measure in the South Indian inscriptions comprises 16 *nāḻi*. It was in vogue till recently. *Padakku* and *tūṇi* occurs in *Tolkappiyam*.[93a] Altekar considers *padakku* as equal to 12 lbs., while according to Princep it is 54 lbs and 4 ozs. (The latter seems to be closer to the author's calculation). The Gujarati commentary on *Gāṇirasara* refers to a *padākku* as comprising 12 maunds[47], which is a very big unit.

Tūṇi consists of 32 *nāḻi* or 1½ maunds. Though this is often found in the inscriptions, it was out of usage. According to *Kaṇakkusāram*[11] it is ⅓ of a *kalam*.

Kalam literally means 'a lot', thereby showing that this term stands for a large volume. It was prevalent till recently in South India. *Kalam* in and around Madras is double that of

the other areas in the South. 96 *nāḻis* or 12 *marakkāls* normally make one *kalam*, which is roughly equal to 3 maunds of rice. The capacity of *kalam* also seems to vary at different places. According to the Tirumukkudal inscription[69] of Vīrarājendra one *kalam* of *Rajakesari measure* was equal to 1 *kalam*+1 *tūṇi*+4 *nāḻi* of *Aruḷmoḻidevan kalam*, thereby showing that a *kalam* of *Rājakesari* measure is bigger than the *kalam*, measured by *Aruḷmoḻidevan kalam*.

Parra or *parai* is of 5 *marakkāls*.[70] It is referred to in the ancient Tamiḻ work *Śilappadikāram*.[94]

Podhi[11] constitutes of 20 *idangaḻis* or 640 *āḻākkus*. *Podhi* literally means a big heap. *Parra* and *podhi* are common measures in Kerala.

Kōṭṭai[95] is another measure peculiar to Tamiḻnādu and Kerala and varies from 21 to 24 *marakkāls*.

The measures in Kerala and Tamiḻnādu are similar in their nomenclature, but they seem to differ in their capacities. The following tables are from the Malayālam work *Kaṇakkusāram*.[11] The figures in the brackets are equivalents worked out by the author.

Table I

360 nelmaṇi	= cavaḍa (13 c.c.)
5 cavaḍa	= āḻākku (65 cc)
8 āḻākku	= chirunāḻi (520 cc)
4 chirunāḻi	= edangaḻi (208 litres)
20 edangaḻi	= podhi (41.63 litres)

Table II

4 chirunāḻi	= prastha (2.08 litre)
4 prastha	= āḍhaka (8.32 litre)
4 āḍhaka	= drōṇa (3.28 litre)
16 drōṇa	= khāri (552.48 litre)

These measures have been in use in Kerala till very recently. These are certain measures which can be traced only in Andhra and Karṇāṭaka regions.

Gidda according to *Vyavahāragaṇita*[96] is ¼ of a *sallage*. The Vardhamānapuram inscription[97] (A.D. 1244) refers to *gidda*. It may be a *gill* or liquid ounce.

Garemata or spoon is referred to in an inscription[98] as a measure of oil, but its quantity is not specified.

Sontige mentioned in the Ratta inscription[99], can be translated as a ladleful.

Citti[100] is also a very small measure and is $\frac{1}{4}$ of a *sola.*

Sallage[101] or *sola*[102] is a most popular measure for grains. According to Pāvalūru Mallaṇa[103], it is a grain measure with a capacity to hold 900 grains. *Sallage* is $\frac{1}{4}$ of a *māṇika* or $\frac{1}{64}$ of a *tumu* according to Wilson[104]. At present it is $\frac{1}{4}$ of a *balla.*[105]

Balla is a common measure referred to in Karṇāṭaka inscriptions[101], for measuring rice, oil, ghee, curd, etc. It is $\frac{1}{4}$ of a *kolage.* In Tulu it is equal to a seer. According to Wilson[107] it is of 48 double handfuls (*anjali*).

Kumca or *kumchamu* as a measure for grains and liquids is found in the inscriptions from Andhra. According to Wilson[108] it varies from 1/10 seer, 3$\frac{1}{4}$ seer, and 8 to 14 seers. *Kumca* is $\frac{1}{4}$ of a *tumu* and equal to 4 *māṇikas. Mummudi Bhimakumca*[109] *Prolakumca*[110] and *kollakumcamu*[111] are the different types of this measure found in the inscriptions.

Kolaga[101] as a measure for grains is common in Karṇāṭaka. Wilson considers *kolaga* as a measure weighing 3 bushels or 1/20 of a *khanduga*[112]. 4 *ballas* make a *kolaga,* according to Rājāditya's *Vyavahāragaṇita.* In Mysore, *Sultani kolaga* was 16 seers, while *Krişnarāja kolaga* was 8 seers and *khararu kolaga* was 10 seers. In South Kanara *sikka kolaga* and *geṇī kolaga* were in vogue. But generally *kolaga* was 1/20 of a *khaṇḍi.*

Tumu, a common measure in Andhra, is 1/20 of a *puṭṭi* or *khaṇḍi.* It is also used as a land measure.

An inscription[113] dated Saka 1230 mentions *biyayumu tumuḍu* (one *tumu* of rice), *minimulu tumu* (one tumu of black gram), etc. *Mummuḍi Bhīmatumu*[114], *Nanditumu*[115], are other types of *tumus. Pandumuneyi*[116] (10 *tumus* of ghee), and *iddumubiyyamu*[117] (2 *tumus* of rice) are also referred to in inscriptions.

Puṭṭi is the biggest cubic measure found in the literature and inscriptions[118] from Andhra and constitute 20 *tumus,* having a capacity of 14941.653 c. inches.[119] It is the same as *khaṇḍi* or *khaṇḍuga. Pella puṭṭi* is a smaller *puṭṭi,* measuring 80 *kumcas,* while *malaca puṭṭi,* which is a bigger one, measures 400 *kumca.*[120] It is also used as a weight equal to a ton and

also used as a land measure.

Khaṇḍuga is the counter part for *puṭṭi* in Karṇāṭaka. *Khaṇḍi* in Mahārāṣṭra and Gujarat are also synonymous. It is a weight as well as a measure of capacity and varies in different places for different articles.

Generally *khaṇḍi* constitute 20 maunds. Since the maund itself differs from place to place *khaṇḍi* also differs. According to Rājāditya 20 *kolaga* make a *khaṇḍuga.* It is difficult to surmise from a Cera inscription[121] whether *khaṇḍuga* represents weight or volume.

There are certain measures which are rarely found in the inscriptions and hardly in literature and they are difficult to be identified properly.

Tauva or tamuva[122] which is ciphered as 'ta' was found in Andhra inscriptions, for measuring green gram, ghee etc., without any specification.

Vajjani of sugar-cane juice is mentioned in an inscription[123] from Dharwar.

Kōṇa of salt and ghee occurs in the same inscription.[123].

Halige and *koda*[124] were used as measures of oil in Karṇāṭaka inscriptions.

The volume measures in general appear to have followed the quarternary system, except in few cases measured by Śukra in his *Śukranīti.*

The regional variations appear to be not merely in the type of usage of a particular measure, (whether as volume measure, weight measure or land measure), but also in actual quatities they represented. Till very recently the measures in Eastern India appeared to have been twice the size of the corresponding Western Indian measures. For example, till recently the *man* was equal to 40 *seers,* but the weight of a *seer* was 32 and 40 *tolas* in Gujarat and Mahārāṣṭra, it was based on 80 *tola* as a *seer* in Bengal and 118 *tola* as a *seer* in Orissa. The name of the measures in Kerala and Tamilnādu remained the same, even though the quantity represented by the corresponding Kerala measure was smaller in volume.

Many rulers appear to have established their own measures, usually larger in size than that of his predecessor, probably to show his greatness. We have such examples in the Coḷa

dynasty in the South and also in Karṇāṭaka. Some of the big temples in the South appear to have had their own measures like *Ādvallān* measure, which is the measure related to the Cidambaram temple, usually larger in volume than the common measures.

It was found difficult to relate these ancient Indian measures to the ancient Western measures, because just as in India, various European regions also appeared to have followed different measures and systems. Neither the names nor the volumes represented by them could be calculated and equated, with these ancient Indian measures.

It can be concluded, that the volume measures in ancient India evolved not on a carefully standardized but on the basis of regional standards and local usages and remained so for long periods of time, as useful basis for various transactions.

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123. *IA*, XII, p. 255.
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CHART I
Measurement of Capacity

Arthaśāstra	Baksāli manuscript and Viṣṇudharmottara purāṇa	Bhaviṣya purāṇa	Varāha purāṇa	Mahāvīra	Śrīpati	Śukra
2 pala=prasṛti		2 pala=prasṛti	2 pala or muṣṭi=prasṛti		2 prasṛti=setika	10 karṣa=padartha
2 prasṛti=kuḍava	4 pala=kuḍava	2 prasṛti=kuḍava	4 prasṛti=kunchi	4 sodaśika=kuḍava	4 satika=kuḍava	
4 kuḍumbha=prastha	4 kuḍava=prastha	4 kuḍava=prastha	8 kunchi=prastha or puṣkala	4 kuḍava=prastha	4 kuḍava=prastha	10 padārtha=prastha
4 prastha=āḍhaka	4 prastha=āḍhaka	4 prastha=āḍhaka	4 prastha=āḍhaka	4 prastha=āḍhaka	4 ptasthe=āḍhaka	5 prastha=āḍhaka
4 āḍhaka=droṇa	4 āḍhaka=droṇa	4 āḍhaka=droṇa	4 āḍhaka=droṇa	4 āḍhaka=droṇa	4 āḍhaka=droṇa	8 āḍhaka=armana
16 droṇa=khāri	16 droṇa=khāri	16 droṇa=khāri		4 droṇa=māṇi 16 droṇa=khāri 5 khāri=pravartika		20 armana=khārika
20 droṇa=kumbha	20 droṇa=kumbha	2 droṇa=kumbha	20 droṇa=kumbha	4 pravartika=kumbha (400 droṇas)	15, 20 and 25 droṇa=kumbha	
10 kumbha=vāha			200 droṇa=vāha	4 pravartika=vāha	200 droṇa=vāha	

CHART II

ATHARVA VEDA

	Kri	Ma	Pa	Pra	Adh	Dro
Krisṇala	1					
Maṣaka	5	1				
Pala		64	1			
Prastha			32	1		
Āḍhaka			128	4	1	
Droṇa			512	16	4	1

BAKSHALI

	Pa	Pra	Ku	Pra	Adh	Dho	Kha
Pala	1						
Prasṛti	2	1					
Kuḍava	4	2	1				
Prastha	32	8	4	1			
Āḍhaka	128	32	16	4	1		
Droṇa	256	128	64	16	4	1	
Khāri	4096	2048	1024	256	64	16	

VARAHAMIHIRA

	Dry Measure				*Liquid Measure*			
	Pa	Ku	Pra	Adh	Pa	Ku	Pra	Adh
Pala	1				1			
Kuḍava	4	1			8	1		
Prastha	16	4	1		32	4	1	
Āḍhaka	64	16	4	1	121	16	4	1

KAUTILYA

	Ku	Pra	Adh	Dro	Kha	Kum	Vāha
Kuḍumbha	1						
Prastha	4	1					
Āḍhaka	16	4	1				
Droṇa	64	16	4	1			
Khāri	1024	256	64	16	1		
Kumbha	1280	320	80	20	1.25	1	
Vāha	20480	51200	12000	200	12.5	10	1

MAHAVIRA

	Sho	Ku	Pra	Adh	Dro	Mani	Kha	Pra	Kum
Śodasika	1								
Kuḍava	4	1							
Prastha	16	4	1						
Āḍhaka	64	16	4	1					
Droṇa	256	64	16	4	1				
Māṇi	1024	256	64	16	4	1			
Khāri	4096	1024	256	64	16	4	1		
Pravartika					80	20	5	1	
Kumbha								5	
Vāha								4	1

CHART III

Carakasamhita

6 vaṁśa	= marīṣa
6 marīṣa	= sarśapa
8 sarṣapa	= taṇḍula, rati
2 rati	= māṣa
2 māṣa	= yava
2 yava	= andaka
3 māṣa	= śana
2 śana	= drankṣana, kola
2 drankṣana	= karṣa, suvarna, viḍalapada, pāṇitala
4 karṣa	= palam, muṣṭi, vilva
2 pala	= prasṛti
2 prasṛti	= kuḍava, añjali
2 kuḍava	= māṇika
2 māṇika	= prastha
4 prastha	= āḍhaka
4 āḍhaka	= droṇa, kalaśa, ghata unmāṇa, armana
2 droṇa	= sūrpa, kumbha
2 sūrpa	= goni, khāri, bhāra

Sarangadhara Samhita

Kalingamāna

12 sarṣapa	= yava
2 yava	= rati, gunja
3 rati	= valla
4 valla	= māṣa
4 māṣa	= śana, taṅka, niṣka
2 śana	= karṣa
2 karṣa	= śukti
2 śukti	= palam
2 palam	= prasṛti
2 prasṛti	= kuḍava
2 kuḍava	= māṇika
2 māṇika	= prastha
4 prastha	= āḍhaka
4 āḍhaka	= droṇa
2 droṇa	= sūrpa
2 sūrpa	= khārika

Magadhamāna

30 paramāṇu	= trasareṇu
6 trasareṇu	= mariṣa
6 mariṣa	= rājika
3 rājika	= sarṣapa
8 sarṣapa	= yava
4 yava	= gunja or rati
5 gunja	= paṇa
6 gunja	= māṣa, hema, dhānyaka
4 mūṣa	= śana, dhārana, tanka
2 śana	= kola, kṣudraka, vataka, drankṣana
2 kola	= karṣa, akṣa, pichu, pani, manika, vidālapada
4 karṣa	= palam, muṣṭi, amsa, vilva, prakuncha
2 palam	= prasṛti
2 prasṛti	= kuḍava, anjali
2 kuḍava	= mānika, śarāva
2 śhrāva	= prastha
4 prastha	= āḍhaka
4 āḍhaka	= kalaṣa, droṇa, nalvaṇa unmana, ghata
2 kalaśa	= sūrpa, kumbha
2 sūrpa	= droṇa, goni, vāha
4 droni	= khāri

5

Weights in Ancient India

COMPARED with the measurement of length and volume, measurements of weights are later developments, the reason being that weights and balances are complicated equipments unlike the linear measures, where parts of the human body can be used.

Weights and balances were used for weighing precious metals[1] in the beginning and later on for other commodities. As in the case of linear and cubic measures, in the weights also minute particles like trasareṇu, aṇu, etc., are mentioned in the literature. The weights of sesame, paddy, etc., are of hardly any use while measuring materials other than precious metals, few medicinal herbs and spices. Since the evolutions of smaller weights were associated with the weighing of precious metals and precious stones in ancient India, it is being dealt with separately later on. Palam is the recognized practical weight measure in general use in ancient India and was perhaps equated with the weight of a handful of paddy. This seems to be reasonable though a primitive approach.

Palam or *pala* as a common weight standard can be traced from literature and epigraphs. *Pala* is considered equivalent to 1/40 of a *viss* or *vīsa* in Tamiḻ country. Since *viss* is equal to modern 3 lbs, 1 oz and 5.94 dr, the *pala* would be 34.5 grams.

A *muṣṭi* of paddy also approximately weighs 32 grams. Wilson[2] considers *palam* to be weighing between 35 to 39 grams and according to the revised table in 1846, the *palam* is considered to be equal to 1 oz and 3.75 grams, that is 34.61 gms.

The term *palam* occurs in several South Indian inscriptions. To quote a few examples, during the time of Rajendra Coḷa I[3] (1020 & 1022 A.D.) the gift of a bell metal (bronze) plate was measured in *palam*. Cooked vegetables prepared in the temples were also measured in *palams* in an inscription dated 1264 A.D., during the time of Jātavarman Sundara Pāṇḍya[4]. In several inscriptions sugar was weighed in *palam*[5].

An interesting equivalent for *palam* is rendered in a 11th century inscription from Tirumalavāḍi (Trichy district) during the time of Rājarāja[6], when a silver vessel weighing 5 *palams* or 77¾ *kaḷanjus* was given by the Queen to the temple of Vaidyanātha. According to this inscription a *palam* is equivalent to 15.55 *kaḷanju*. Since a *kaḷanju* weighs approximately 45 to 50 grains, *palam* must be 46 to 51 grams approximately, during 11th century A.D. in Trichy district.

Prastha is considered as a weight by Mahāvīra[7] for weighing metals other than gold and silver and is equal to 12½ *palas*. Kalhaṇa[8] in *Rājataraṅgini* refers to the erection by Lalitāditya Muktāpida of Bṛhad Buddha (Great Buddha), which reached up to the sky (colossal image) with thousands of *prasthas* of copper. According to the Petersburg dictionary a *prastha* is estimated as equal to 16 *palas*. *Prastha* as a cubic measure is equal to 16 handfuls. Hence, it can also be considered as equal to the weight of 16 handfuls or 500 to 550 grams.

Sei generally occurs in the inscriptions and literature from North India. In the Gujarati commentary on Śrīdhara's *Patigaṇita*[9], a *sei* is equivalent to 16 *paili* or 1/16 of a *kalasi*. Since *kalasi* is 16 *maunds*, *sei* may perhaps be equivalent to a maund. Dr. Bhandarkar[10] considers *sei* as of 20 *pāyalis*, while Pandit Ram Karna[11] opines it as of 15 *seers*. 64 handfuls make a *sei* according to Takkur Pheru's *Gaṇitasāra* which is about 2.24 kg[12].

A few inscriptions are acquainted with *sei*. In the Manglana stone inscription[13], it is mentioned as a weight for korada corn, while in the Bhinmāl stone inscription[14] it occurs as a weight for wheat. In Lalrai stone inscription of Lakkanapāla and Abhayapāla[14], it is referred to as a weight for barley and corn.

Seer is a different weight from *sei*. In Madras State 8 *palams* constitute a *seer* and is 1/5 of a *viss*. Considering *viss* or *vīsa* as 3 lbs, 1 oz, 5.94 dr, a *seer* would be 275 to 280 grams approximately. *Seer* in Gujarat is of 466.5 grams or 1/40 of a maund. The seer seems to have varied considerably throughout the ages. According to Abul Fazl, the *seer* which was used formerly in Hindustan was equal to the weight of either 18 *dams* or 22 *dams*. In the beginning of Akbar's reign, however, it had the standard of 28 *dams* in weight, but it was raised to 30 *dams* before the *Ain* was written. The *dam* should have weighed 222.7 grains. The *seer* of Jehangir was of 36 *dams* and of Shah Jehan 40 *dams*. Hence the *seer* varied from 600 to 850 grams. At present generally a *seer* is considered as equal to 466.5 grams. The Greek *mina* was 430 grams, while the Hebrew *mina* 500 grams.

Viss or vīsa is a weight standard, used till recently in South India. The term '*vīsai*' in Tamiḻ, literally means division and *vīsam* the fraction 1/16. Perhaps *viss* may be a derivation from the Sanskrit word '*vihita*' meaning distributed. Till recently it was equal to 5 *seers* or 40 *palams* or 1/8 of a *maund* or 3 lbs, 1 oz, 5.94 dr. Alberuni[16] mentions a measure named *bisi* equal to 1/12 of a *kalasa* or ¼ of a *māna* or 1/16 of a *panti*. Whether these have any connection with *visa* is difficult to ascertain. He compares *bisi*, with *Khwarizmian sukhkh*, which is 1/12 of a *ghur*.

In an inscription of Vikramāditya II (732 A.D.)[17] from Karṇāṭaka *visa* is mentioned alongwith several gifts. 5 *vīsa* on each *bhanda peru* (*heru* is 60 *seers* or sack of corn) was mentioned.

Sir Walter Elliot[18] gives the representation of two old iron weights. One is circular, weighing 3 lbs, 1 oz, 4 dr and has on one side the boar crest (Cālukyan emblem) and above it a sun and moon and on the other it is engraved "Pramādīcha Sam, vi 1" i.e. Pramādīcha Samvatasara, 1 *vīsa*. The other is octagonal weighing 12 ozs, 2 dr. It has on the front only a

sword, with the sun and moon and below them the words 'Pramādīcham vi ¼, i.e. 'a quarter *vīsa* stamped in Pramādicha Samvatsara'.

Māna, mānako, māṇangu and māṇangulu (*Telugu*) are derivation from the Sanskrit work *māna* to measure. Wilson[19] considers *māna* as a derivation from Persian *māneh* but his argument is not valid, since *maneh* is a small weight. The *māneh* varies from 400 to 900 gram in Persia, Egypt, Syria, etc.

In the Gujarati commentary on *Pāṭigaṇita*[9] in one table a *mān* is considered to be equivalent to 24 *palas*, which is a small measure. Pāvaluru Mallaṇa[20] gives varying tables for *maṇangulu* ranging from 40 to 80 seers.

An inscription dated 732 A.D. during the time of Vikramāditya II[17] from Karṇāṭaka refers to *māna, peru, veesa* and *bhanda peru*. *Māna* occurs in Bhinmāl stone inscription while *mānaka* occurs in Bijapur inscription[11] and *māṇi* in Lekhapaddhadi for weighing wheat, barley etc.[21] *Maṇangulu* is a common weight for corn in the Andhra inscriptions.

All these terms may be somewhat referring to the customary Indian scale of weight *man* or anglicised *maund*. The *māna* in Karṇāṭaka was still recently 16 *seers*, while in Madras it is 40 *seers* (about 25 lb). *Man* varied from 20, 40, 46 and 64 *seers* with difference in the weight of *seer* also. According to the Indian Regulation VII 1833, 80 *tolas* are equal to a *seer* and 40 *seers* a maund. *Tola* weighs 180 grains. Hence *man* weighs

$$\frac{(180\times80\times40)}{15\times10}=38.5 \text{ kg}$$ [22].

In the Mughal period *man* was the customary Indian scale of weight, 40 *seers*=1 *man* was almost used throughout except for certain regions in the East. North West and in Deccan, where it either intermingled or coexisted with the other systems of weight. *Man-i-Akbari* was based on the *seer* of 30 *dams* and was equivalent to 55.32 lb while *Man-i-Jehangiri* was based upon the *seer* of 36 *dams*, and was equal to 66.38 lb. *Man-i-Shahjehani* was measured by the *seer* equalling to 40 *dams* and hence *man* was 73.76 lbs.

The English factors, who visited Surat found ½ *man* equaling to lbs 27 or 27.5 lbs in 1611 A.D., while in 1614 A.D., the ½ *maṇa* weighed 33.19 lbs. *Mana* varied with different materials.[23]

Just as the basic measurement *talents* of Hebrews (30 kg) and of Greeks (25.8 kg), *mana* or *maṇangu* or *maund* was the basic unit for bulk weight in India.

Bhāraka or *bāra* literally means bulky or heavy. 20 *tulas* make one *bhāra* according to Kauṭilya[24], Śrīpati[25] and Sārangadhara[26], while 10 *tulas* make one *bhāra* according to Mahāvīra[7] and Hemacandracārya.[27] There is a great deal of confusion with the measure *tula* itself. *Tula* consists of 100 *palas* according to Hemacandra[27], 200 *palas* according to Mahāvīra[7] and 500 *palas* according to Śrīpati[25] and 2400 *palas* according to *Pāṭigaṇita*.[9] In *Dvyāśraya* commentary[28] of *Pūrnakalaśa gaṇi, achita* or *sakaṭ* (cart load) is equal to 10 *bhāras*. According to Alberuni, *bhāra*, which is 2000 *palas* is almost equal to the weight of an ox.

Salt seems to have been weighed in *bhāraka* in an inscription from Bhutai in Panchmahal district in Gujarat, dated the 3rd year of Toramāṇa.[29] *Bhāra* occurs as a measure for sugar, jaggery, Bengal madder cotton and coconut in Arthuna inscription[30] of Paramāra Cāmuṇḍarāya (V.S. 1136). *Bāra* as a measure of salt occurs in the Hastikuṇḍi inscription[11] of Rāṣṭrakūṭa Dhavala.

20 *maṇangu* make a *bhāram* in South India. It also varies from 20 to 28 *tulāms* the latter being 100 to 200 *palams*. *Bhāram* is equivalent in some places to 960 *seers*[31]. 4 *khaṇḍis* make 1 *bhāra* in Sāvantwādi district. Though *bhāra* was in usage, till recently, it was not found in the mediaeval inscriptions or texts from South India.

According to Wilson[30] *bhāra* is used as a weight for weighing cotton in Gujarat, equal to 20 *dhāris* of 48 *seers* or 960 *seers*, while according to Moreland[32] and Yule[33] *bhāra* and *candil* (perhaps *khaṇḍi*) are one and the same. The weight *bhāra* seems to differ with metals and cotton. The Arabian weight *bahar* is equivalent to 20 *maunds*. Perhaps this may have some connection with *bhāra*. The units *seer, vīsa, maṇangu* and *bhāram* seem to have entered Tamilnādu through Andhra and Karṇāṭaka influence. They are almost absent in Cera, Cola and Pāṇḍya records.

Hāraka was a measure of weight of barley corn mentioned in the Lalrai inscription of Kelhaṇadeva (V.S.1167)[14], Sevaḍi stone inscription of Aśvarāja[34] and in Arthuna inscription.[30] Dr. Bhandarkar suggests that *hāraka* is the same as the Marathi '*hāra*' meaning a larger basket of particular form and of loose texture. 24 *mana* or 6 *sei* is a *hāri*, according to the Gujarati commentary on *Pāṭigaṇita*[9]. In the Kutch district, a *hāra* is half of a *kalasi*, that is 8 *maunds*, while in Navsari it was 7 *maunds*. Perhaps, this may be like the weight *heru* of Karṇāṭaka, which varies from 1/10 of a *khaṇḍi* to 1/20th of a *khaṇḍi*.

Kalasi according to the Gujarati commentary on *Pāṭigaṇita*[9] is of 16 *sei*. *Kalasi* is 16 *maunds* in some parts of Gujarat. In Jamnagar for measuring milk, it is a cubic measure of 5 *seers* and for measuring grains and other liquids it is 20 *maps*.

Kalasi is used, as a measure for oil in the Janvara inscription of Gajasinghadeva and Kelhaṇadeva (V.S. 1218)[35] and as a weight for butter in the Bhinmāl inscription of Udayasimhadeve (V.S. 1336)[10]. Alberuni[16] equates *kalasi* with *khwarizmian ghur* or equivalent to 12 *bisi* or 48 *mān*.

The weight of *kalasi* varies in different places according to Mirat-e-Ahmadi[36]. In certain areas in South India till recently, *kudam* and *cembu*, meaning a pitcher is used as measure for oil.

Mūḍa was equal to 10 *kalasis* according to the Gujarati commentary on Śrīdhara, which is also current till recently, in Kutch. *Mūṭa* or *Mūṭaka* of *Lekhapaddhati*[37] is 100 or 24 *maunds* according to the editor, while Dr. D.C. Sircar[38] testifies that *mūḍa* is equal to 40 *pakka seers*.

Jagaḍu Shah's distribution of thousands of *mūḍas* of corn, during the three years of great famine in 1313 A.D. to 1316 A.D. was described in *Jagaḍucarita*[39] and *Prabandha Pañsaśati*.[40]

In the Arthuna inscription[30] of Paramāra Cāmuṇḍarāya (V.S. 1136), salt and barley were measured by *mūṭaka*. Perhaps *mūḍa* or *mūṭaka* may be a *desi* word derived from Tamiḻ word *muṭṭai* meaning a bagful and generally measures either 48 or 64 Madras measures. *Mot* stands for load in Hindi and *muth* for bullocks' rack saddle in Marathi. *Mūḍa* or *mūṭaka* might have been derived from any one of these.

Padakku mentioned in the Gujarati commentary on *Pāṭigaṇita* is of 3 seers. *Padakku* occurs only in South Indian inscriptions with a capacity of 28 or 42 litres.[41] This term *padakku* can be traced from the ancient Tamiḻ work *Tolkāppiyam*.[42]

Khaṇḍugu, khaṇḍika or khaṇḍi, seems to be of big bulk and more common in Karṇāṭaka and Andhra areas.

In a copper plate from Nagamangala (777 A.D.)[43], Prithvi Kongaṇi Mahārāja Vijaya Skandadeva donated several *kaṇḍugas* of land for garden, house site, irrigation along with waste land, for a Jain temple. The editor suggests as much of a land needed for sowing a *khaṇḍugu* or 3 bushels of seed. In another inscription[44] 10 *khaṇḍugas* of paddy were mentioned as a gift to a brāhman.

During the reign of Bhīma II[45] (Cālukya), *Māhipāla* gave 350 *pāśas* of land yielding 4 *khaṇḍikas* to one Mādhava.

Several inscriptions[46] refer just to *kha* which stands for *khaṇḍuga* or *khaṇḍi*. *Khaṇḍuga* and *khaṇḍaga* in *Kannaḍa* is synonymous with *khaṇḍi* in Marathi and Gujarati.

At present *khaṇḍuga* is used in Kannaḍa and Telugu speaking areas as a weight of 192,200 *tolas* for silk, sugar, drugs and cotton. As a dry measure it varies from 409,600 (Belgaum), 134,440 (Mysore) and 128,000 tolas (Coorg) in different places. *Khaṇḍi* varies with different articles also. *Khaṇḍi* at Masulipatnam has 3 weights, namely 488 lbs. for tobacco, 500 lbs for metals, hardware, etc., and 560 lbs. for sugar, dates and soft articles.[47] Generally 20 *kolages* are equivalent to a *khaṇḍi*. In the Portuguese records in the 17th century, it is spelt as *candil*.

Tula comprises 500 *palas* according to *Anuyogadvārasūtra*[48] and Śrīpati's *Gaṇitatilaka*[25], while it is 200 *palās* according to Mahāvīra[7]. Hemacandra[27] and Sārangadhāra[26] refers to a *tula* of 100 *palas* which constitute 400 *tolas*. *Tulām* varies from 100 to 200 *palas* in South India. It varies considerably and it is also considered as equal to 5 *viss*. To give an example, in Coimbatore district 100 *palams* make a *tulām*, a *palam* being 8 *tolās* each weighing 180 grains troy. Hence the *tulām* would be 7.8 lbs. Wilson[49] considers *tulā* as a weight between 145 to 190 ounces (4 to 5 kg). *Tolu* of Gujarat seems to correspond to this unit and considered to be equal to 10 *seers*.

There are certain measures which are current in Andhra and Karṇāṭaka which are given as follows.

Kalage was a common measure mentioned in these inscriptions[50]. 8 *seers* constitute a *kolage* in Hassan district. Till recently several *kolages* were in usage. Sultani *kolage* of 10 *seers*, *sikka kolage* and *geni kolage* are a few to mention. Normally *kolage* is 1/20th of a *khaṇḍi*. This term *kolage* is also used as a volume measure.

An inscription in the time Raṭṭa chief Kārtavīrya (1024 A.D.)[21] refers to *mana, balla, sallaga heḍaru* and *kolage*.

Salige or *solage* is 1/64 of a *kolage*.

Heḍaru may be perhaps *heru* or *goṇi* measuring 1/20 of a *khaṇḍi*.

Weights relating to precious metals and stones

Weights and balances were first used for weighing gold dust and not, as might be supposed, for commercial transactions. The earliest commercial use of weighing was about 2500 B.C. in the Aryan civilization in the Indus sites[52] and perhaps to a limited number in the Sumerian cities of Mesopotamia.[53] In Egypt all the evidence shows commerce by barter only, the first indication of the use of the balance in ordinary trade being as late as 1350 B.C. The earliest pictorical evidence of weighing in Egypt, dating back to the period of Dynasty V, shows the balance in use only by goldsmiths and jewellers or for weighing gold ingots of one of the temple treasuries.[54]

Sanskrit name for balance is *tulā*, which occurs first in *Vājasaneyi Saṃhitā*[55] in relation to weighing gold (*hiranyakāra tulā*). The term *māṣa* as a weight occurs as early as *Kathaka Saṃhita*[56], thereby showing that seeds were used for weighing precious metals.

Using seeds for weighing precious metals is a common practice all over the world. Even at present the weight standard *carat* (3⅕ grains) is actually the weight of the seed of carob tree (*caratonia silique*), an evergreen Mediterranean tree.

In ancient India, the seeds of *guñja* (*Abrus precatorius* or *Adenanthera pavonina*), *yava* (barley), *sesame* seeds, etc., were used for weighing precious metals and stones. Weighing by *guñja* or *ratika*, is still in vogue, in case of precious metals,

precious stones, and medicinal herbs.

Weighing by *guñja*, *ratika* or *manjādi* is a common phenomenon all over India. Weight is also bound to vary slightly, since the seeds cannot be of the same size and weight. Several authors, have tried to come to certain conclusions, but nothing can be taken as the perfect weight.

In literary works like *Manu*[57] and *Yājñavalkya*[58], *trasreṇu* (particle) *likṣa* (louse), *rājasarṣapa* (black mustard seed) and *gaurasarṣapa* (white mustard seed) are given as weights. These are very minute measures. *Trasareṇu* is just discernible as a glancing particle in the slanting beams of the morning (or afternoon) sun, coming into a room through a chink or orifice of a window. This seems to be only an imaginative measure since actual measure of this dust particle will not be possible with the instruments then available. Further there can be no practical use for such a weight.

8 *trasareṇu* make a *likṣa* and 3 such *likṣa* make a *rājasarṣapa*, 3 *rājasarṣapa* were equal to a *gaurasarṣapa* and 6 of the latter, *yava* according to Manu[57] and Yajñavalkya.[58] Alberuni[59] testifies 4 *mundri* as a *pada* and 4 *pada* as a *kala* and 6 *kala* as a *yava*. Hence the weight of *kala* and *gaurasarṣapa* perhaps may be the same.

Caraka[60] and Sārangadhāra[61] in their medical texts give a table which is slightly different. 6 *trasareṇu* form a *marīci* and 6 of the latter form a *rājika*, 3 *rājika* form a *sarṣapa* and 8 of the latter a *yava*. 864 *trasareṇu* make a *yava* according to this calculation, while according to Manu[57] and Yājñavalkya[58] 432 *trasareṇu* make a *yava*. Thus the basic measurement itself seems to be controversial and varies by 1:2 ratio. Sārangadhara gives two measurements namely Magadha and Kalinga. According to the former 4 *yava* make a *guñja* and the latter 2 *yava* make a *guñja*. This vast difference may be either due to the type of seeds or perhaps the *Magadha mana* itself is double that of *Kalinga mana*. Moreover there is a different reading for *marici* as *mariṣa*. The former stands for a speck in the beam of sunlight, while the latter for seeds of *amaranthus*.

Mudri, mundri or mundrigai is mentioned rarely in the literature. 96 *mudris* make a *yava* according to Alberuni.[59] In South India the term *mundri* stands for the fraction 1/320.

This fraction seems to be very important, since *ratika* or *guñja* is 1/320 of a *pala*, according to Kauṭilya[12], Manu[57], Yājñavalkya[58] and Bakṣāli manuscript[14]. Alberuni has omitted the term *ratika*, hence the difference in his calculations.

Gaṇḍaka is mentioned only by Mahāvīra[65], which is ¼ of a *guñja*. The weight of *gaṇḍaka* may be perhaps equal to a *yava*. A mode of reckoning by fours is also termed as *gaṇḍaka*.

Leaving aside all these measures, which seem to be impractical, it seems that actual measure starts with *taṇḍula*, *ratika* or *guñja*, which still remains as jewellers' weight in India.

Taṇḍula was equated with a weight of 8 *gaurasarṣapa*, according to Varahāmihira[66] and Caraka.[70] Use of *taṇḍula* or unhusked rice seems to be common all over India. It is termed as *nel* in Dravidian languages and is ¼ of *rati*.

Ratika or *guñja* or *manjādi* (*Abrus precatorius* seed, Sanskrit-*guñja*, *ratika*; Hindi-*rati*, *ghungechi*; Bengali-*kunch*; Tamil-*gundumani*; Telugu-*guriginja*; Malayālam-*kākani*; Kannada-*gunj*; Guj-*chanothi*, *rati*, *guñja*) is the measure commonly used by jewellers all over India. Though the seeds have several varieties of colour, the red one with the black eye is usually used, as the weight for gold and silver. The term *mañjādi* is found mostly in South Indian literature and inscriptions. Someśvara in *Mānasollāsa* considers *guñja* and *mãñjādi* as synonymous[57]. while in Hemādri's *Vratakhāṇḍa*, he quotes Viṣṇugupta as stating 2 *guñjas* as a *mañjādi*.

Adenanthera pavonina (Marathi-*thoraligunj*; Hindi-*barigumchi*; Tamil and Malayālam-*anaikunḍumani* or *mañjādi*; Telugu-*gurivenda*) unlike the creeper *abrus* is a large tree, bearing scarlet red seeds, which are also used as jewellers' weights. The seed roughly weighs 4 to 5 grains or two of *abrus* seeds.

Several modern scholars have weighed the *ratika* (*abrus*) and has arrived at different conclusions. According to Prinsep[69] 1.875 grains constitute a *rati*. *Adenanthera* according to Elliot[70] is 5.3 grains. 1.934 grains make a *guñja* according to Wilson.[71]

Tavernier[72] gives different values for *rati* at different places for diamonds and pearls. *Mangelip* (*mañjādi*) weighed 1⅜ *carats* or 4.36 grains in Golconda for diamonds, 5 grains in

Goa and 7 grains in Bijapur also for diamonds. Pearl *rati* was 2.77 grains. *Mañjādi* according to Wilson is of 4 grains and equal to a *carat*.

Ancient writers have used *guñja*, *ratika* and *anḍi* as synonymous. From the data of the ancient Indian writers, it is not clear whether they took *abrus* or *adenanthera* as a *rati* or *guñja*. When Manu has stated 2 *rati* as a silver *māṣa* and 5 *rati* as a gold *māṣa*, perhaps, the former must have been *adenanthera* and the latter *abrus*. In the same way, when Bhāskarācārya[73] has stated that 8 *guñjas* make a *ratika* and 5 *ratika* a *valla*, he must have taken *guñja* for *abrus* and *ratika* for *adenanthera*. Varāhamihira's *anḍi* comprising 4 *yavas* may be *ratika*. In the Gujarati commentary on Śrīdhara's *Pāṭigaṇita*[9], there were two tables for gold, 5 *guñjas* make a gold *māṣa* and 3 *ratika* make a gold *valla*, while for silver, 5 *guñjas* make a *māṣa*. It is not clear, whether the author considers *ratika* and *guñja* as belonging the same type of seeds.

Both *abrus* and *adenanthera* are in usage as jewellers' weights. In Mahārāṣtra and South India two *rati* make a *mañjadi*, thereby showing the former as *abrus* and the latter *adenanthera*.

Valla (it is a type of wheat) would be equivalent to 3 *guñjas* of 2 *ratikas* according to Bhāskara and in the commentary on Śrīdhara's *Pāṭigaṇita*.[9] Weighing by *vāl* is still common in Gujarati and varies from 1½ to 2 *rati*. There is a variation in *Mirat-e-Ahmadi*[74], where 3 *māṣa* is considered as a *vāl*.

Māṣa (*Phaseolus radiatus*) occurs as early as in *Kathaka Samhita*.[75] 5 *guñjas* make a *māṣa*, according to Manu[57], Yājnavalkya[58] and Kautilya[72] in measaring gold. Mahāvīra refers to it as *paṇa*.[65] Śukra[76] and Bhāskara[77] differ from others. The former measures *māṣa* as of 10|*guñjas* and the latter 10½ *guñjas*. In the Gujarati commentary on Śrīdhara's *Pāṭigaṇita*[9], there are two tables, one mentioning 5 *guñjas* as a *māṣa* and the other 3 *ratika* as a *valla*. The latter table coincides with Bhāskara[73], who considers 3 *guñja* as a *valla*. 4 *kākaṇis* constitute a *māṣa* according to Nārada and 4 *anḍis* (*guñja*) according to Varāhamihira[66]. Analysing various authors Colebrook[77] has stated that there are four types of *maṣas* comprising 5, 6 and 16 *ratikas* and a silver *maṣa* of 2 *ratikas*.

All these differences may have been due to the *guñja* or *ratika* and whether it is *adenanthera* or *abrus*.

Prinsep notices *māṣa* of 2, 4, 5 and 16 grains, while Colebrook[78] considers it as 17⅜ grains and Coderington found *maṣa* varying between 10, 16 and 20 grains.[79]

Coins which were unearthed from Taxila weigh from 2, 5 to 2.86 grains. These Mr. Walsh attribute to the silver *masaka* coins.[80]

8 *rati* make a *māṣa* according to Babur's Memoirs.[81]

In 17th century Gujarat *māṣa* varied from 10, 16 and 20 grains.

The term *māṣa* was common till recently as jewellers' measure and varied in different states. To state a few examples, in Madras the weight of *māṣa* was 15 grains, in Sholapur and Nasik it was 16 grains, but in Kolaba only 9 grains. On the whole 8 *guñjas* are considered as a *māṣa*. At present it is stated as 1/12 of a *tola* and hence it will be about 15 grains or 1 gm.

Suvarṇa or *karṣa* comprises 16 *māṣas* in weighing gold. Here also since the *māṣa* itself differs, the weight of *suvarṇa* also differs.

80 *guñjas* make a *karṣa* according to Manu[57], Yajñavalkya[58], Kauṭilya[62], Amara and Mahāvīra.[65] Bhāskara differs from others by stating 168 *guñjas* as a *karṣa*, while according to Śukra 100 *guñjas* is a *karṣa*. In weighing silver Mahāvīra refers to a *karṣa* or *puraṇa* of 80 *guñjas*.

Śukra[82] used the word *karṣa* for weighing rice in one place and stated that *karṣa* was 1/100th of a *prastha*, thereby indicating that it must have been used for weighing other commodities also. In Babur's memoirs[81] 4 *māṣa* is considered as a *tang* and 5 *māṣa* as a *miskal*.

Suvarṇa as a weight was of 5 *dharaṇas* or 50 *guñjas* according to *Abhidānappadīka*.[83] *Karṣa* was also used as a coin denomination weighing one *karṣa* in weight. It was referred to as *kāhapana* as well as *suvarṇa* in the Buddhist literature.[84] *Suvarṇa* was referred to alongwith *śatamāna*, in *Śatapatha Brāhmaṇa*.[85] Cunningham considered *karṣapaṇa* as the seed of *Bellerica Myrobalan* (*Terninalia Bellerica*) which reaches upto 140 grains in weight.[86]

Karṣapaṇa was a silver coin weighing 32 *ratis* (57.6 grains), while *suvarṇa* was a gold coin weighing 80 *ratis*(146.4 grains).[87] In Ceylon a coin of the *kaḷanju* weight is called *kāhapaṇa*.[88]

Ḍharaṇa consists of 10 *palas* or 3200 *guñjas* according to Manu[57] and Yājñavalkya[58] with regard to measuring gold, while Mahāvīra[65] equates it with 40 *guñjas* or 8 *paṇas*. Bhāskara's[76] view seems to have been accepted in the Gujarati commentary on *Gaṇitasāra*.[9] Varāhamihira's[66] *dharaṇa* is 1/10 of a *pala*. Since *pala* is of 320 *guñjas*, *dhāruṇa* must be 32 *guñjas* only according to Varāhamihira.

Silver *dharaṇa* is 32 *kriṣṇalas*, according to Manu[57], Yājñavalkya[58] and Mahāvīra.[65] Kauṭilya differs from others by stating that 16 *māṣa* or 20 *saibya* seeds, constitute a *dharaṇa*. If Kauṭilya's silver *māṣa* is considered as equal to ½ *guñja*, then *dharaṇa* will be of 8 *guñja* seeds.

Manu's gold *dharaṇa* is heavier by 100 times than the silver *dharaṇa*, while Mahāvīra's[65] gold *dharaṇa* is 40 *guñjas*, silver *dharaṇa* is 52 *guñjas*. Bhāskara's[73] gold *dharaṇas* is the lightest, weighing 24 *guñjas*, which was also accepted by Gopālabhata.[89] Bālambhaṭa[90] was also of the same opinion, eventhough he considered *dharaṇa* and *kalañju* as synonymous. These vast numerical differences may perhaps be due to the type of *guñja* used, whether *abrus* or *adenanthera*. Perhaps the similarity in the names may be a coincidence and have no connection in the weights concerned, or the value of gold might have gone up in Bhāskara's time.

Śatamāna was 320 *ratikas* or 160 silver *māṣas* or 10 *ḍharaṇas* according to Manu[57] and Yajñavalkya[58]. Yājñavalkya applied *pala* to *śatamāna* and Vijñāneśwara equates it to a *niṣka*. *Śatamāna* literally means measuring by hundred and it is believed that *śatamāna* was 100 *ratis*. However, *śatamāna* was of 320 *ratis* as quoted by Manu and Yājñavalkya. In *Abhidānappadīpika* a *pala* is considered as equal to 100 *guñjas*. Since sometimes the term *śatamānapala* occurs, *śatamāna* and *śatamāna pala* may be one and the same.

From the etymology of the word *śatamāna* and from *Śatapatha Brāhmaṇa* certain scholars[91] adhere to the 100 *ratis* as a *śatamāna*, since there is a definite reference to a *śatamāna* of 100 parts i.e. 100 ratis. The verse "*suvarṇam rajatam hiraṇyam*

nānārupatayā śatamānam bhavati śatāyur vai puruṣah," meaning that gold and silver will be the fee for the sake of variety to the manifold form of the deity, and that *dakṣiṇa* will be *śatamāna,* since the human being lives for one hundred years. Karaka the commentator of *Katyāyanasrautasūtra* has described the *śatamana* as *vrittakarou raktika śatāmanau*[92] (literally two round objects, weighing one hundred *ratis*)

Dr. D.C. Sircar analysing these facts came to the conclusion that 100 pieces making a *śatāmana* must be the South Indian *mañjadi (adenanthera povonina)* which is double the size of *ratika. Mañjadi* roughly weighs between 4 to 5 grains. Dr. Sircar, on the basis of epigraphic evidence also had opined that the non-Aryan weight system was adopted for *śatamāna.* The use of the multiple 16 is considered to be non-Aryan, since it was used by the pre-historic people of Indus valley. The *śatamāna* must be referring to 100 pieces of some non-Aryan measure probably *mañjādi.*[92] This may be a correct view, since 96 *mañjādis* are considered as a *tola* in certain parts till recently. Instead of 96, a round figure of 100 might have been used.

During the time of Babur 96 *ratis* or 12 *māṣa* were considered as a *tola.* It has been observed by Prinsep[69] that there is a closer accordance with the English gold assay scale, inasmuch as 96 *ratis* in a *tola* exactly represented the 96 carat in the gold assay pound and the *dhān* (धान्य grain) which was the quarter grain. Perhaps *śatamāna* may be referring to the present *tola.* This reminds one, about the weight measure hundred-weight, which is equal to 112 pounds troy or 50.8 kg and not hundred-pound weight as the name suggests.

The British apothecaris' ounce and troy ounce consists of 480 grains or 30 grams. If *adenanthara* is considered *śatamāṇa* weight it will be somewhat closer to an ounce.

Pala which is considered synonymous with *śatamāna* is accepted by most of the authors as consisting of 4 *karṣas* or *dharaṇa* or 320 *guñjas.* Bhāskara[73] though accepted 4 *karṣa* as a *pala* in weight, it was 672 *guñjas* according to him while one of the tables of the Gujarati commentary on Śrīdhara's *Pātigaṇita* it was 480 *ratikas.* There is an enormous difference between Bhāskara[73] and others on this.

The glorious silver image of Parihāsakeśava (Viṣṇu) erected by Lalitāditya Muktāpīda was made of thousands of *palas* of silver, according to Kalhaṇa.[92] Since the phrase 'thousands of *palas*' was used, a *pala* cannot be a very big measure.

Pala and *muṣṭi* are considered as synonymous. *Muṣṭi* depicts a volume. Hence the weight of the amount of any substance perhaps paddy, that can he held in a *muṣṭi* or handful, must have been taken to be a *pala. Pala* or *muṣti* is considered as 4 *tolas* by Manu and 4 or 5 *tolas,* according to Yājñavalkya[58]. If we consider the present *tolā* which is 11.66 gms, according to Manu, it will be 46.64 gms, while according to Yājñavalkya[58] it can be 58.3 gms.

Tola, as the name itself suggests, is that which is measured in a *tulā* (balance). This is rarely used in ancient literature as well as in inscriptions. In *Rājatarangiṇi*[94], Lalitāditya Muktapīḍa is said to have placed eightyfour thousand *tolakas* of gold for preparing the image of Muktakeśava (Viṣṇu). Stein identifies *tolaka* with *tola* and considers it to be equal to ¼ of a *pala.* Prinsep has given several weights for *tola* varying from 18.7 to 19.4 grains at different places.

In 17th century A.D., in Surat and Ahmedabad a tola of gold weighed 50 grains, while a *tola* of diamond weighed 58 carat or 62 *ratis.* Taking *rati* as 2.75 grains, a tola of diamond would be 172.5 grains.

The present jeweller's *tolā* is 11.662 gms. or 180 grains in most of the places and is known as *Bombay bullion tolā. Bombay tolā* is also used for weighing saffron and spices. In certain places it varied for gold as in Amaravati district in Mysore where a *gold tola* weighed 216 grains. But at present *tolā* weighing 11.66 gms has been used all over India. It is not out of place to mention that the Egyptian gold standard *beqa* weighed 12.96 gms and the Persian silver standard 11·53 gms.

*Kaḷanju (Caesalpinia crista; Kuberākṣi-Sanskrit; karanja-*Hindi, Gujarati, Kannada: *nata natta karanja*-Bengali; *gajaga*-Marathi; *gacaca kaya*-Telugu; *Kazanchikuru*-Malayalam-*Kazhichikay*-Tamil) is a term which often occurs in South Indian epigraphical records. *Kaḷanju* is actually the name of a prickly climbing species of caesalpina, the weight of the seed

varying between 45 to 50 grains. The earliest reference in Tamil literature is from *Purananuru*.[95] Since in certain inscriptions the attribute *por* is added before *kalanju* (porkalanju), it can be considered that either *kalanju* is a measure of gold or a gold coin. In an early Pāndya inscription of Māranjadaiyan[96], it is clearly stated that a *kalanju* is equivalent to a *Krṣnakaca*. Another inscription refers to a *kalanju* as being equivalent to a *niṣka*. A 11 century Cola inscription from Tirumalavādi equates *palams* with 15 *kalanjus*.[97]

No definite calculation can be made from these statements.

Someśvara in *Manasollasa*[67] considers 30 *mañjādi* as a *kalanju*. The same calculation occurs in a late Sanskrit work *Ratna parikṣa*.[98] Bālambhata considers two *guñjas* as a *majjatika* or *manjista* which is 1/20 of a *kalanju*.[99] *Kalanju*, or *mañjadi* and *kunri* (*kunrimani*) were very common weight standards for gold. A Cola inscription from Kañchipuram[100] refers to 18 *kalanju*, 3 *mañjadi* and 1 *kunri* thereby showing that *mañjadi* is a bigger unit (adenanthera) than *kunri* (abrus).

Weights and balances in ancient India

Excavations conducted during the past two decades in a number of sites revealed objects that were identified as weights. In Taxila[102], Besnagar[103], Kaundinyapura[104] Sālihundam[105] and in other sites have disclosed several weights belonging to as early as 3rd millinium B.C. Though the origin of Indus system was independent, its relationship with Mesopotamian and Egyptian systems is within the range of probability. The system used in binary in case of smaller weights and decimal in the case of larger ones, the succession being in the ratio 1, 2, 4, 8, 16, 32, 64, 160, 320, 640, 800, 1600, 3200, 6400, 8000 etc. The ratio which was maintained by the Indus people seems to have been adopted in the later period to some extent and the number 16 became deep-rooted in the numismatic ratios. The unit of weight at Mohenjodaro has the calculated value of 0.875 gram and the largest weight 10.970 kg.

Even though a large number of weights were found, it is surprising that only a few scale pans had come to light. A few scale pans (of red pottery, copper and iron with holes for suspension prove the existence of common balances.[108] A

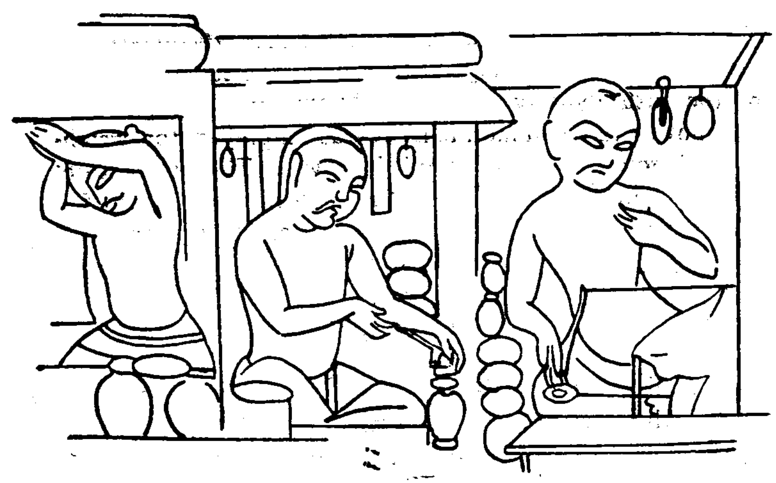
PLATE I

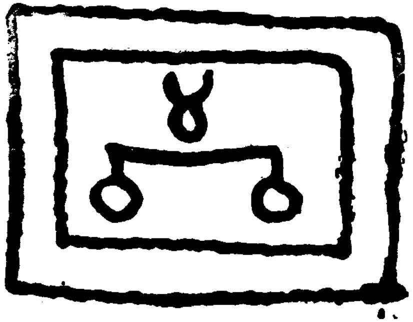
One Pan Balance on Greco-Buddhist Relief



PLATE II

Balance in Ajanta Caves





Coin from Rajgir

painting in cave no. 17 in Ajanta (6th century A.D.),[109] represents a trader weighing in a double pan balance. On the obverse of an oblong coin from Rajgir,[110] a common balance is depicted.

Specimens of *naraji* or one pan balance have been found in Arang in Madhya Pradesh and also in Sirpur (8th Century A.D.).[111] The earliest of this type at Pompeii is of 78 A.D. In the panels depiciting *Sibi Jāṭaka* in Amaravati, and Nāgārjunakoṇḍa[112], one-pan balances have been identified. In the Gandhāra sculptures[113] the single-pan balances have come out very clearly. A relief on the back side of the Mira temple at Ahar shows a grocer using a balance for weighing.[113a]

The prototype of the beam balance is frequently represented on scenes depicting the weighing of precious metals in Egypt from the fifth dynasty onwards. Drawings in Papyrus and tombs showed that common balance was employed for weighing large ingots of precious metals in Egypt. The most ancient balance so far discovered is in Egypt constructed at the 5th millennium B.C. It was made of lime stone, 8.5 cm. long with a fulcrum hole in the middle and suspension hole at each end for the ends that supported the scale.[114] Roman craftsmen had an excellent bronze balance during the time of Constantine (337 A.D.).

The zodiacal sign *tulā* or libra shows the antiquity of common balances. The ancient Indian name for balance was *tulā*. This term occurs in *Vājasaneyi Samhita*[55] with reference to weighing gold (hiraṇyakāra tulā), thereby showing that

weighing was limited to precious metals. *Śatapatha Brāhmaṇa*[115] refers to weighing of a man's good and evil deeds in the next and in this world. Balances were considered among the household objects according to Vaṣiṣṭha.[116] Falsifying of balances was a social crime according to Āpastambha[117] and the person who used false balances was to debarred from śrāddha ceremonies. Buddha considered cheating through false balances and deriving profit thereby, as a kind of *mithyaajīva*[118].

Every four months, the government has to check balances according to Kauṭilya[119] while according to Manu[120], checking should be done every six months; Yājñavalkya[121] prescribes heavy punishment for those who make and use false balances.

Falsification of balances by deceit is mentioned in Amos (VIII 4-5) in the old Testament and it is condemned in Proverbs (XX:23). Using different kinds of weights to one's own advantage is also mentioned in Deuteronomy (XXV:13) and Proverbs (XX 10 and 23).

Kauṭilya enumerates sixteen types of balances. Of these ten varieties are of light weight with single-scale pan. Beginning with a lever of six *aṅgulas* in length and of one *pala* in the weight of its metallic mass, there were ten different types of balances with levers increasing successively by one *pala* in the weight of their metallic masses. According to this description the length and weight of balances can be tabulated as follows:

Type No.	*Length*	*Weight in metallic mass*
1.	6 aṅgulas	1 pala
2.	14 ,,	2 ,,
3.	22 ,,	3 ,,
4.	30 ,,	4 ,,
5.	38 ,,	5 ,,
6.	46 ,,	6 ,,
7.	54 ,,	7 ,,
8.	62 ,,	8 ,,
9.	70 ,,	9 ,,
10.	78 ,,	10 ,,

These balances were used in weighing probably all kinds of commodities. The heavy balances were of six types. Of these *Samavarttatulā* had its lever 72 *aṅgulas* long and it weighed 53 *palas* in metallic mass. Kauṭilya explains these types of balances as "a scale-pan of 5 *palas* in the weight of its metallic mass being attached to its edge, the horizontal position of the

lever, when weighing a *karṣa* shall be marked (on that part of the lever) where held by a thread, it stands horizontal". To the left of the mark, symbols such as 1 *pala*, 12, 15 and 20 *palas* shall be marked. After that, each place of tens upto 100 shall be marked. In the place of *akṣas* the sign of *nandi* shall be marked (*akṣas* are the place of five and multiples of five. *Nandi* is the symbol of Swastika).

Parimani is the largest type of heavy balance mentioned by Kauṭilya. It has a lever of 16 *aṅgulas* and 106 *palas* of weight in metallic mass. On its lever marks per 20, 50, 100, etc., are indicated. The weights of the public balance (*vyāvahārika*), servants balance (*bhājani*) and balance of the harem (*antapura bhājani*) were 95, 90 and 85 *palas* these balances.

The heaviest type of balance was made of wood, with a lever eight cubits long. The lever had measuring marks and it was erected and fixed on a peacock like pedestal. Counterpoise weights were used in weighing heavy commodities.[122]

In *Mahā Nārada Kassapa Jātaka*[123], a weighing house is referred to. Weights were added gradually one by one on the weighing scale and when the weights were placed the end of the balance would be swung up.

Yājñavalkya[124] refers to the practice, to draw a line on the wall of the weighing house to ensure accuracy in weighing. When the weights and the things to be weighed are on a level with the mark made on the wall at the weighing house, the wetght is supposed to be perfect. He refers to experts in weighing (*tulādhāranavid*).

Manasollāsa[125], a 12th century work by the western Cālukyan king Someśwara Bhulōkamalla, describes details about the balance (tulalākṣanam) used by the lapidaries in ancient India. He prescribes a heavy beam (daṇḍa) measuring about 12 *aṅgulas* in length at the ends of which there should be two rings (mudrika) for hanging the pans which should be made of bell metal (kānsya) with four string holes for suspension. The central rod (kaṇtaka) measuring about 5 *aṅgulas* should be placed under an arch (toraṇa) by means of holes at ends. The arch should be held by a string while weighing and the vertical position of the central rod should determine the exact weight. Obviously here the author describes the common balance with two pans.

Thus the antiquity of weighing can be traced back to Indus civilization and Vedic period. Weighing appears to have started with precious metals in the beginning, since for other commodities barter must have been in practice. Though archaeologists have tried to prove the existence of decimal and binary systems, from the literature mostly the use of binary systems is available with regional variations.

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67. *Manasollāsa*, Vol. I, p. 70, Tulalakṣanam.
68. *Vratakhaṇḍa*, Vol. I, 52-53.
69. *Useful Tables*, p. 97.
70. *Numismato Orientalia—Coins of South India*, p. 47.
71. *Hobson Jobson*, p. 777.
72. *Travels in India*, Vol. II, ch. XVIII, p. 89.
73. *Līlāvati*, ch. I.
74. *Mirat-e-Āhmadi*, 1924, p. 164.
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77. *Miscellaneous essays*, I, p. 551.
78. *IHQ*, VII, p. 693.
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82. *Nītisāra*, IV, 5. 483.
83. *Abhidhānappadīpika*, 479, 480.
84. Jātakas, V, p. 306, text, p. 305.
85. *Śatapatha Brāhmaṇa*, XII, 2, 22.
86. *Coins of Ancient India*, p. 45.
87. *JRAS*, 1901, p, 876.
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93. *Rājataranginī*, IV, p. 143,
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102. *Taxila*, II, p. 508-509.
103. *Archaeological Survey of India—Annual Report*—1914-15, p. 86.
104. *Excavations of Kaundinyapura*, 1960-61, p. 17-18, 1963-64, p. 15-16.
105. *Salihundam*, p. 161.
106. *Further excavations at Mohenjo-Daro*, p. 400-465.
107. *Mohenjo Daro and the Indus civilization*, II, p. 589-597.
108. *Further excavations of Mohenjo-Daro*, p. 435, 476, 477.
109. *Sārthavaha*, p. 240, fig. 37, depicting Vissantara Jātaka.
110. *Catalogue of coins in the British Museum—Ancient India*, p. XXXVIII and CXXVI, pl. XVI, 8-10, XXXI, 2-4, 10.
111. *Deccan College Rescarch Institute*, Vol. 18, Taraporewalla Volume p. 5-7.
112. *Amaravati sculptures in the Madras Government Museum*, p. 143, 228, 30, PL XXVII, fig. 16, PL V, p. 35.
113. *Indian Temples*, Greeco-Budddhist Reliefs-British Museum no. 42-43.
113a. *Arts Asiatiques*, XI, p. 63-64, fig. 6,7.
114. *The legacy of Egypt*, p. 176.
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115. *Śatapatha Brahmaṇa*, II, 2,7, 33.
116. *Vasiṣtha dharma sūtra*, XIX, 1823.
117. *Āpastambha dharma sūtra*, Vol. II, pt. I, II, 6, 19,
118. *Dighanikāya*, Vol. III, p. 136, 8:9;43,
119. Kauṭilya, II, 19, 51.
120. Manu, 8.403.
121. Yājñavalkya, Vol. II, p. 240.
122. Kauṭilya II 19:12-28.
123. Jātaka, Vol. VI, p. 112.
124. Yājñavalkya II, 100-102,

Measurement of Gold

Prameyārtha manjuṣa commentary on Jambu divapannatti	Arthaśāstra	Manu and Yājnavalkya, Brahma-purāṇa	Alberuni	Mahāvīra	Bhāskara	Gujarati commentary on Śridhara's Pātigaṇita (14 century A.D.) Table I	Table II	Śukra's Nītisāra
		3 likṣa=rājasarṣapa	4 mudri=pada					
		3 rājasarṣapa=gaurasarṣapa	4 pada=kalā					
16 svetasarṣapa=māṣaka		6 gaurasarṣapa=yava	6 kalā=yava				8 sarsavi=yava	
2 māṣa=gunja	2 māṣa=gunja	3 yava=krişnala	4 yava=aṇḍi	4 gaṇḍaka=guuja			2 yava=ratika	
5 gunja=karma māṣaka	5 gunja=suvarṇa māṣa	5 krişnala=māṣa	4 aṇḍi=māṣa	5 gunja=paṇa	3 gunja=valla	5 gunja=māṣa	3 ratika=valla	10 gunja=māṣa
16 karma māṣaka=karṣa	16 suvarṇa māsa=karṣa	16 māṣa=suvarṇa	16 māṣa=karṣa	16 paṇa=karṣa	16 māṣa=karṣa	16 māṣa=karṣa		10 māṣa=karṣa
		10 pala=dharaṇa (according to Manu)		8 paṇa=dharaṇa	8 valla=dharaṇa		8 valla=dharaṇa	
4 karsa=palam	4 karsa=pala	4 suvarṇa=pala		4 karṣa=pala	4 karṣa=pala	4 karṣa=pala	20 dharaṇa=pala	
					16 valla—gadyāna		16 valla—gadyāna	

Measurement of Silver

Manu & Yājñavalkya	Kauṭilya	Mahāvīra
2 krişnala=māṣa	88 gaurasarṣapa	2 gunja=māṣa
16 māṣa=dharaṇa	16 māṣa or saibya seeds=dharaṇa	16 māṣa=dharaṇa
		2½ dharaṇa=karṣa or purāṇa
10 dharaṇa=śatamāna		4 karṣa or 10 dharaṇa=pala

6

Measurement of Time in Ancient India

ALL over the world, measurement of time was invariably related to natural phenomena, associaied with the movements observed among the celestial bodies. In ancient period, the sky was the giant clock and calendar as well as an almanac. Even before realising the details of the movements of planets and positions of [the stars, people could still appreciate and understand the phenomena, like day and night, the waxing and waning of the Moon at regular intervals and [monsoons occurring at definite intervals. Time was understood as a continuous motion that cannot be stopped, neither hurried nor delayed. It was considered to be without beginning and without end.

Regarding the celestial factors that governed the time, sun was the most important one. Even the ancient astronomers, for whom earth was the centre, the sun was given the place next to the earth. The recurrence of days and nights at regular intervals was attributed to the revolution of the sun and not to the rotation of the earth. The day is apparnetly the most obvious and simple unit of measurement. A day is a period of 30 *muhūrtas* (24 hours). Its principal characteristic of

alternate daylight and darkness repeats itself in regular cycles.

Waxing and waning of the Moon is another obvious unit in helping to determine the months. The waxing and waning occur with good regularity. The seasons arrive in a consistent sequence. These are the natural phenomena which governed the time factor in the ancient world. These natural factors helped to serve the day-to-day needs of the society, which did not require any great accuracy, because of the simple and leisurely life. With the first streaks of Sun's rays, man and animals started their chores and even the birds came out of their nest. With the setting of the Sun, men and animals went for resting and the birds flocked inside their nests. During the day, men had to do his daily routine of collecting food, fire-wood and after a tiresome day had to retire for rest. The variations in the seasons helped man to decide about the farming operations, the type of protective dresses to wear and plan his day-to-day operations depending on the weather conditions, which he could predict fairly well to meet his limited needs.

It is difficult to say definitely, as to when and how the counting of time began. According to eminent scholars, the Egyptians were using a calendar as long ago as 4236 B.C. The Jewish religious calendar starts with the supposed date of creation by Jehovah, while the Chinese chronology starts from 2391 B.C.

The Vedic Aryans had the knowledge of time in relation to sunrise, noon, sunset, day, month, fortnight, seasons, half year (*ayaṇa*), year and *yuga*. The term *muhūrta* is found in Ṛg Veda in the sense of 'moment'. while in Brāhmaṇa literature it denotes a division of time, namely one thirtieth of a day (48 min or $\frac{4}{5}$ hour).

As the activity of man became more and more organised and as his social links also became well established into civilized living, he felt the need to subdivide day into definite divisions to organise his activities in a more systematic manner. That is to say, as the civilization progressed, the need for appreciation of the time element also grew. The ancient Indians divided the day initially into 30 *muhūrtas* or 60

nālikas as the practical measures of time. Thus the simple reckoning appears to be 360 days a year, 30 days a month and 30 *muhūrtas* a day, two *nālika* equalling a *muhūrta*.

The *nālika* itself had to be further subdivided into smaller units, for greater accuracy. This, particularly was needed to calculate more precisely, the planetary positions, in astronomical and later on in astrological calculations, as also in musical and poetic meters.

In the past all over the world, the calculations based on the movements of the planets and constellations were based on geocentric idea, that is, on the concept that earth was stationary, with other planets of the zodiac moving around it. Clear-cut ideas about the zodiac was understood in India by about 500 A.D. as can be seen from *Sūryasiddhānta* and *Āryabhaṭīya* (500 A.D.). Āryabhaṭa[2] was the first known astronomer-mathematician in India, who expounded the theory of revolution of earth which was refuted by later writers in India. This important discovery of Āryabhaṭa was not known to the West, who still attribute the credit for this theory to Copernicus, the Polish astronomer, who in the 16th century A.D. clearly demonstrated, that the planets including the earth revolve on their own axes and move in orbits around the Sun. Even in the 17th century A.D., when Galileo[3], the Italian astronomer, though confirmed the Copernicus theory, had to repudiate the theory later, because of the confrontation with the inquisition threats. Thus, eventhough Āryabhaṭa had given this correct concept in 5th century A.D., both in India and abroad this fact was ignored and India appears to have accepted the theory again, only after the West had accepted the Copernican theory in 17th century. It is, however, interesting to note, that even before Āryabhaṭa, Aristarchus of Samos[3], Greek mathematician proposed that sun was the hub of our planetary system and earth was revolving around it, even as early as 3rd century B.C. Pythogoras and Philotaus also followed the same doctrine. This was, however, refuted by Aristotle and later on by Ptolemy.[3]

Thus a very important concept in the field of time measurement, even though it came to light as early as 3rd century B.C., it required nearly 19 centuries to pass off before getting

the recognition due to religious bigotry and ignorance of the masses. This very fact makes the naming of the 1st Indian satellite as Āryabhaṭa quite aptly and reflects the correct thinking of the people concerned in naming the satellite.

In relation to the development of time concepts certain interesting factors are worth consideration at this stage. According to ancient astronomers, the zodiac was divided into 360°. The year which consisted of 12 months of 30 days comprises 360 days. The divisions of time in the chart I, except in Mahāvīra's *Gaṇitasārasamgraha*, were divisions into 360 unit. The year, according to Jupiter's cycle is also 60, which is one-sixth of 360. This number 360 is not an imaginary number. That is the only number divisible by the numbers 1 to 9 except 7. Taking advantage of this, the zodiac must have been divided into 360. Since the number 360 is convenient for calculations, this must have been kept as the base by the astronomers and astrologers.

After the Vedic age, astronomers like Āryabhaṭa I, Brahmagupta I, Varāhamihira and Bhāskara I made their contribution to the Indian astronomy. Alongwith this, astrology also developed, which interested the planetary movements linked to the destiny of the man. In this discussion the time factors mentioned in the books on astronomy or *jyotiṣa* and mathematics are considered to start with, since they formed the main basis for time measurements in ancient India.

The term *jyotiṣa* is derived from the root 'jyut' or 'dyut', to shine and therefore it is a science of the movements of the luminous bodies. Another expression for it, is *nakṣatra darśana* or observation of stars. Astronomy (as derived from *astron*, a star and *nemo*—to classify or arrange) is a science, which deals with the distributions, motions and characteristics of heavenly bodies. As has already been stated, since the movements of the planets govern the time, *jyotiṣa* or astronomy is the most important science, to be considered while discussing evolution of concepts on time. Since astronomy needs precise calculation mathematics goes hand in hand with astronomy. It is no wonder that ancient astronomers were eminent mathematicians also.

In the following study the various entities of time measure-

ments that were used in ancient India are given, starting from the smallest unit of time used in the literature of different periods. There are some variations in the usage and concepts relating to many of the smaller units, eventhough the concepts relating to *nālika and muhūrta* remained uniform. All the variations are summed up in the comparative charts (charts I and II).

Division of the day into thirty *muhūrtas* has been accepted by all the ancient Indian seers. Considering a *muhūtra* as of 48 minutes, the equivalents of the other smaller units in terms of modern minutes and seconds have been calculated by the author in chart I, to understand the proper relationships between these otherwise confusing terms of unitage of time. The equivalents in seconds and minutes are given within brackets wherever possible.

The terms like *paramāṇu, aṇu, trasareṇu* and *āvali* which occur in ancient Indian literature seem to denote very minute items of matter, including minute span of time. It is difficult to evaluate them with any of the present known measures. More information is available on the following measurements of time, even though they appear to denote different lengths of time according to different scholars.

Truṭi, which is also a very small unit of time, has been mentioned by several authors, as giving varying time equivalents. According to Kauṭilya[4], *truṭi* is equal to 0.06 seconds, while according to *Bhāgavata*[5] and *Brahmapurāṇa*[6] it is 0.0005 seconds. Vaṭeśvara and Nārada[8] consider *truṭi* as the time taken to pierce a lotus petal, which is equivalent to 0.0C0008 seconds of the modern time measurements. Musical works[9] refer to a *truṭi* of 8 to 16 *nimeṣas* or 1/10 of a *guru*. A *guru* is the time taken to pronounce a *guruvāksara* or a long consonant. Thus the term *truṭi* appears to connote different lengths of time according to different authors.

Tatpara (speck) constitute 100 *truṭis* according to Bhāskara[10] and Śrīpati[11] (0.003 sec). Vaṭeśvara calls 100 *truṭis* as a *lava*, which works out to 0.0008 second. The term *vedha* in *Bhāgavata*[5] and *Brahmapurāṇa*[6] also is said to consist of 100 *truṭis*, but is a slightly bigger unit (0.047 sec).

Guruvākṣarocchāranakāla or the time taken to pronounce a long consonant was considered as a unit of time. It is generally accepted as a space of 0.4 second. The term *laghuvākṣara* (short consonant) and *guruvākṣara* (long consonant) connote different time factors. The time taken to pronounce a short consonant is one *laghu* and two *laghus* make a *guru* in poetical works.[9]

Mātrā is a fixed time limit, which is still in usage, in both musicial and poetical works. The time taken to pronounce five short syllables (*laghuvākṣara*) is considered as a mātrā according to Bharata's *Nāṭyaśāstra*[12] and other works on music.[13]

Kallinātha, in his commentary upon *Sangītaratnākara*[14], draws a clear distinction between the *mātrā* of the poetical meter and the *mātrā* of musical meter. In connection with the poetical meter, the time taken to pronounce a short syllable is meant by the word *mātra*, while in the musical time measurement (tāla) it should be regarded as the time measured in pronouncing 5 short syllables. Here also certain works on music and dancing differentiate the *mātrā* between *mārgi* and *deśi* styles. In the former, the time taken to pronounce 5 *akṣaras* stand for a *mātrā*, while in the latter it is equal to 4 *akṣaras*.

In the ancient Tamil work *Tolkappiyam*[15], twinkling of the eye is considered as a *mātrā*. In Tamil the time taken to crack the finger is also called *mātrā*.

Uchchvāsa (0.75 sec) was considered as 1/7 of a *stoka* by Mahāvīra.[16]

Prāṇa is the time taken to pronounce 10 *guruvākṣaras*, according to Brahmagupta[17] and *Sūryasiddhānta*[18] (4 sec). Vaṭeśvara[7] and Bhāskara[10] refer this term as *asu* (4 sec).

Lava is a controversial unit and seems to be a superficial measure. The time taken to pierce a lotus petal is considered as *lava* according to *Vaṭeśvara siddhānta*[7], while it is the time taken to pierce 800 petals by a needle according to musical works.[9]

Lava according to Kauṭilya[4] constitutes 2 *truṭis* (0.12 sec), while according to Vaṭeśvara it is equal to 100 *truṭis* (0.008 sec). According to *Bhāgavata*[5] and *Brahmapurāṇa*[6], 300 *truṭis* make a *lava* (0.142 sec). It is to be noted that all these authors used a different concept of time for their *truṭi*. Mahāvīra

considers *lava* as a bigger unit of time, consisting of 49 *uchchavāsas* (37.4 sec), that is 7 *stokas*. It seems that Jains must have taken number 7 as the figure because of its being the largest indivisible unit number.

Kṣaṇa, according to Monier Williams, is a moment of twinkling of the eye or any instantaneous point of time. *Kṣaṇa*, according to *Bhāgavata*[5] and *Brahmapurāṇa*[6] is of 5 *nimeṣas* (1.28 sec), while according to the *nyāya* works of Śrīdhara[19] and Udayana[20], *kṣaṇa* is the smallest unit of time (0.0035 sec). In contrast to this, *kṣaṇa*, mentioned in *Abhidhānacintāmaṇi*, is a bigger unit of 4 seconds.[22]

A late Tamiḻ work *Tāḷasamudram*[21], gives an entirely different meaning for *kṣaṇa*. When 8 lotus petals are kept one over another and picked with the needle, the time taken to prick a single petal is *kṣaṇa*.

Kṣaṇa, is the smallest unit of time according to Sāranga-deva.[14] He considers *kṣaṇa* as 1/8 of a *lava*, which is in relation to poetic meter.

Nimeṣa is the most common unit of time which, however, varies with each and every author. *Nimeṣa* literally means a wink or twinkling of the eye. According to *Vaijayanti*[23], it is the time between two *akṣarapatakas*. 4 *truṭis* make one *nimeṣa* according to Kauṭilya, while (0.24 sec) 3000 *truṭis*, according to Bhāskara (0.09 sec); 10,000 *truṭis* according to *Bhāgavata*[5] and *Brahmapurāṇa*.[6] *Nimeṣa* is omitted by Āryabhaṭa, as well as Mahāvīra.[16] In modern usage a *nimeṣa* is put as the equivalent of a minute.

Kāṣṭha also varies with each and every author for its duration of time. It is 5 *nimeṣas* according to Kauṭilya[4] (1.2 sec), 15 *nimeṣas* according to *Bhāgavata*[5] and *Brahmapurāṇa*[6] (6.4 sec), 18 *nimeṣas* according to Manu[25] and Bhāskara[10] (1.6 sec). *Nyāya* works of Śrīdhara and Udayana[20] consider it as equal to 3.2 seconds. *Kāṣṭha* referred to in *Vedāṅgajyotiṣa*[24] is equal to 1.16 seconds.

Palam mentioned by Bhāskara[10] and Vaṭeśvara[7] is of 24 seconds. This may be considered as equal to *vināḍi* of Brahmagupta.[17]

Kalā has been accepted by several writers as equivalent to 30 *kāṣṭhas*. On calculation, according to Kauṭilya, a *kalā* will

be of 36 seconds, while it will be 48 seconds according to *Siddhānta Siromaṇi*.[10] *Manusmriti*[25] *Viṣnupurāṇa*[26] and *Siddhānta Śekhara*[11] refer to a *kalā* of 96 seconds.

Works on music refers to several types of *kalās*. Bharata mentions three different types of *kalās*. *Kalā* in the *citra* style is of 2 *mātrās*, in *vriti* style is of 4 *mātras* and *dakṣina* style is of 8 *mātrās*. Bharata also refers to a *kalā* or 6 *nimeṣas*. The changing value of *kalā* is conspicuous in latter works on music. In *Sangītacūdamaṇi* of Jagadekamalla and *Sangītamakaranda* of Nārada[13], *kalā* is equated with half of *laghu*, the latter consisting of the time taken to pronounce a short vowel.

Kalā mentioned in *Vedāṅgajyotiṣa*[24] is a bigger unit of time. According to this work, a *kalā* will be equivalent to 2.4 minutes and 603 *kalās* would make a day.

On the contrary, *kalā* mentioned in *Abhidhānacintāmaṇi* seems to be a very small unit of time comprising only 8 seconds.[22].

Nāḍika, *nālika* or *ghaṭika* generally indicate 24 minutes; this has been explained by several authors, while describing *ghaṭi* or *kapala* (clepsydra or water-clock). The Indian water-clock is an arrangement for measuring, by means of the water and a jar or bowl, the duration of *nadi*, *nadika*, *ghati* or *ghatika*.[27]

In *Sūryaprajñapāti*[28], the water-clock is said to be made of a thin plate of brass or copper, capable of holding a *prastha* of water weighing 12½ *palas*. It had a small hole at the bottom through which water entered into the cup, when it was floated in water contained in a bigger vessel. In 12 *nāḍikas* the vessel would be filled 183 times. Hence within a *nāḍika* 15¼ *prasthas* of water would get filled.

In the Buddhist work *Divyavadāna*, a water-clock is described in a detailed manner. At the bottom of a water-jar holding a *drōṇa* of water, a hole should be made of a gold pin. The pin must be made of gold of a quantity of *suvarṇa*, drawn out four *aṅgulas* in length, quite round or square. The water will be completely emptied during a *nālika*.[29]

In *Sūryasiddhānta*[30] also the *nāḍika* is determined by a water-clock. A copper vessel (in the shape of the lower half

of a water-jar), which has a small hole in its bottom has to be placed upon a clean water in a basin. It sinks exactly 60 times in a day and night. This represents 60 *nāḍikas* per 24 hours. Brahmagupta's water-clock also tallies with this.

According to Kauṭilya[32], the duration of the time required for the passage of one *āḍhaka* of water to pass out of a pot, through an aperture of the same diameter as that of a wire of 4 *aṅgulas* in length and made out of 4 *suvarṇamāṣaka* is a *nāḍika*. The diameter of the wire of 4 *suvarṇamāṣakas*, when drawn into 4 *aṅgulas* length, is not mentioned.

In Tamiḻ the water-clock is termed as *nāḻikai vāṭṭil*, through which a *naḻi* or *aḻakkus* of water is made to drip down and the time taken for the *vaṭṭil* to be emptied is a *nāḻikai*.[33] Dividing the day into *nāḻi*, which is equal to 24 minutes, is still in usage in Tamiḻ-speaking areas and is used in South Indian almanacs.

Muhūrta is the only term where almost all the writers are unanimous in stating that it is $\frac{1}{30}$ of a day. The thirty-fold division of the day as well as night is vaguely mentioned in a single passage in *Ṛg Veda*.[34] This has been compared by Zimmer[34] with the Babylonian concept of sixty-fold division of the day. The division of the day into 24 hours was first proposed by the Greeks.

Ahōrātra (day and night) is the most natural phenomenon comprising 30 *muhūrtas* or 24 hours. It is measured from sunset to sunset by Babylonians and Mohammedans. A Hindu day starts with the first streaks of the rising sun. Here again there are controversies. Āryabhaṭa[35] has propounded two systems, *audhāyika* (the beginning of the day with sun rise at Lanka) and *ardharārika* system (beginning of the day at the midnight at Lanka), Brahmagupta accepts the mean sunrise at Lanka, while Bhāskara[37] follows the mean sunrise at Ujjain. Varāhamihira[38] in his epicyclic cast in the *Suryasiddhānta* in *Pañcasiddhāntika* follows the *ardharātika* system, Lanka is an imaginary island in Indian ocean having the same longitude as Ujjain (75°.52′ East of Greenwich), but situated on the Equator.

If the length of the day is measured with an accurate clock, it is variable throughout the year. The day has to be reckoned

either by *nakṣatra* or *tithi* in the Hindu calendar. For religious purposes to fix up festival days, the Hindus, Babylonians and Greeks followed the lunar day which is known as '*tithi*' in the Hindu calendar. This is practical, since calculation through a visible sign (moon) is easier than other celestial bodies, which are not so easy to locate through the naked eye.

Vāma or Prahāra stands for $\frac{1}{8}$ of a day (3 hours). With a view to regulating the occupations of the king, his day and night were each divided into eight divisions of 90 minutes or $\frac{1}{2}$ *praharas*. There used to be a night watch for each *prahara*.

Nakṣatras are the lunar mansions, named according to the conspicuous star group marking the moon's path. The lunar zodiac was earlier divided into 28 parts and later on into 27. In *Ṛg Veda*, it is used in the sense of a star.[39] The earliest reference about *nakṣatras* is from *Atharvana Nakṣatrakalpa*.[40] In *Taittriya*, *Kathaka* and *Maitrāyani Saṁhitas*, *Aitareya Brāhmaṇa*[39] and *Vedāṅgajyotiṣa*[41], the names of the *nakṣatra* were mentioned along with the Vedic deity.

This terms *nakṣatra* has been interpreted in various ways. In *Śatapatha Brāhmaṇa*, it is explained with a legend and is resolved into *na-kṣatra* (no-power). The *Nirukta* refers to the root '*naks*', to obtain. Aufrecht and Weber derived it from *nakta-tra*, 'guardian of night' and more recently the derivation from '*nak-kṣatra*' which means 'having rule over night' seems to gain acceptance.[39]

The Indian names for the *nakṣatras* differ from the Greek astronomical names, as can be seen from the following table:

TABLE I

	Indian Name	*Astronomical Name*
1.	Aśvini	Arietis
2.	Bharaṇī	Musca
3.	Kṛttikā	Aleyni
4.	Rohiṇī	Aldebaran
5.	Mṛgaśīrsa	Orionis
6.	Ārdrā	Betelgues
7.	Punarvasū	Pollux
8.	Puṣya	Canori
9.	Āsleṣa	Hydrai

	Indian Name	Astronomical Name
10.	Maghā	Regulus
11.	Pūrva-Phālgunī	Leonis
12.	Uttara-Phālgunī	Denebola
13.	Hasta	Corvi
14.	Citrā	Spica
15.	Swāti	Arcturus (Bootis)
16.	Viśakhā	Libra
17.	Anūrādhā	Scorpionis
18.	Jyeṣthā	Antarus
19.	Mula	Scorpii
20.	Purvāṣāḍha	Sagittarii
21.	Uttarāṣāḍha	Sagittarii
22.	Śrāvaṇa	Aquilae Ablair
23.	Dhaniṣṭha (śraviṣṭha)	Delphin
24.	Śatabhiṣak	Aquarii
25.	Pūrva Bhādrapada	Markab
26.	Uttara Bhādrapada	Pegasi
27.	Revatī	Piscium

The *nakṣatra abhijit*, which occurs between *Uttaraṣāḍha* and *Śrāvaṇa* is not counted at present, though mentioned in Vedic literature. The Chinese system of *sieu* had at first 24 *nakṣatras* and later was increased to 28 at about 1100 B.C. They are not integrated with a religious system as in the Hindu and the Greek calendars.

The system of quoting dates by *nakṣatras* is as old as quoting by *tithis*. This system is more prevalent in South Indian literature and epigraphy. As early as the famous story of Kovalan in *Śiloppadikaram*[42] (756 A.D.), *nakṣatras* are mentioned. For example, a day would be distinguished as the 6th *tithi* of the moon in the dark half, with the moon in *nakṣatra Śrāvaṇa*. Thus the day gets a more specific fixation in the lunar month, which has a bright half and a dark half.

Week days are the meeting ground for the calendar all over the globe. The 7 day cycle, is probably a convenient division of the lunar month of 28 days. It is probably helpful for fixing a day of rest after protracted work for a fixed number of working days.

The ancient Vedic Aryans had a *ṣadāha*[43], a cycle of six

days and there were no separate names attached to these days. The Egyptians had a ten-day week or decade, the tenth day being the market day and after marketing people can rejoice.

The Babylonians had at first a week of 5 days, which is approximately $\frac{1}{6}$ of a lunation and later on increased it to 7 days, which is approximately $\frac{1}{4}$ of a lunation. The Babylonians named the day after the planets, in the order of their apparent distance from the earth, and identified them with their chief gods, who were said to have some special power under them.

	1	2	3	4	5	6	7
Planet	Saturn	Jupiter	Mars	Sun	Venus	Mercury	Moon
God	Ninib (Pestilence)	Marduk (king)	Nergel (war)	Shamash (justice)	Ishtar (love)	Nalu (writing)	Sin (agriculture)

Further the day was divided into 24 hours, and each of the 7 gods was supposed to keep watch over each hour of the day in rotation. The day was named after the god, who kept watch at the first hour. Thus on Saturday, the watching god for the first hour is Ninib or Saturn and the day was named after him. The succeeding hours of Saturday were presided over as follows:

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Watching god
1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4 5 6 7 1 2 3 4

The 25th hour is the first hour of the next day and the presiding planet is Sun. Hence Sunday comes after Saturday. To the Babylonians, Saturday was dedicated to the god of pestilence and they avoided work on that day for fear of offending the deity. These week days were observed in pre-Christian era, by Assyrians, Babylonians, Egyptians, Greeks, Romans and Jews.

The great propagandists of the seven-day week were Jews, who conferred on the week days some sanctity by inventing the creation myth, in the opening chapters of the Bible (Genesis ch. 1 and 2). The Jews did not adopt the planetary names for the days, but first, second and so on upto the Sabbath day. The seventh day which was the end day of the Babylonians, was the day of rest for Jehovah after his laborious creation.

Jews attached so much sanctity to Sabbath day that they would not do any work on that day. Taking advantage of this, Romans attacked Jerusalem on the Sabbath day, and carried the city, without a fight, because the Jews would not do such profane things as fighting on a Sabbath day and led by their priests, they expected Jehovah to bring punishment on the offenders for the sacrilege.[44]

The Christians changed the Sabbath day from Saturday to Sunday, since they would not have the same day as the Lord's day as the Jews.

For naming the important days of Christian liturgical year such as Holy Thursday, Good Friday, Holy Saturday, etc., the week days were utilised. Here they had some difficulties. The Jewish festival of Passover, on which Christ is alleged to have been crucified, took place on the first full moon after vernal equinox and it had no reference to week days. The Christians wanted the Resurrection on Lord's day. Hence the Bishops decided that the Easter, that is, the Resurrection of Christ should be considered having taken place on a Sunday, following the first full moon after the vernal equinox. This resulted in having Easter on any day between March 22 and April 25, with an amplitude of 35 days.

Here, it is unlike the Hindus, who have to adjust their religious festivals in relation to Sun and Moon and not in relation to the week days. The Christians have to satisfy theSun (vernal equinox), the Moon (full moon) and the Babylonian seven-day planet hierarchy for fixing the Easter day (day of Resurrection of Jesus). From this pivotal day, the other important religions festivals are determined. For example, Good Friday is two days before Easter and Palm Sunday seven days before Easter Sunday. Hence finding out the date of Easter in a given year is not an easy task.

The Romans had the eight-day week, in which the eighth-day was a market day on which the country people went to the city to sell their product, do their own purchases, and attended to public and religious affairs. In or soon after 250 A.D. the Roman world had the seven-day week using the planetary names, which can be understood from a well-known statement by Dion Cassius (first quarter of the 3rd century A.D.). In his

37th book, he has mentioned the capture of Jerusalem by Pompeii in 63 B.C. on a Saturday, owing to the reverence of the Jews for Saturday (their Sabbath day). He further remarks that the week days, originated in Egypt and it was of recent growth in Rome and was in general use in his days.[41a]

It was the Christian Emperor Constantine who confirmed the venerable day of the Sun as a general day of rest and hereby the seven-day planetary week became definitely substituted for the nondinal eight days week.

Week days in India is also a later development. In the end of *Sārdūlakarnadāna*, in *Divyavadāna* the planets were mentioned but not in the same order of the week days. Venus, Jupiter, Saturn, Mercury, Rāhu and Ketu were mentioned followed by Sun and Moon. According to M. Sylvian Levi, they are not found in the Chinese translation which was translated in 3rd century A D. Jayaswal argues that perhaps they must have been left out in the Chinese translation, because they might have been difficult in translating. This argument does not seem to be valid.[45]

In the second praśna of *Baudhāyana dharmasūtra*[46] during *tarpaṇa* the following verse is mentioned.

"Om, I satiate Āditya; Soma, Angāraka; Budha; Bṛhaspati; Śukra; Śaniścara; Rāhu; Ketu." Since the planets are mentioned in the same order as the week days, perhaps the week days might have been hinted. It is not very certain whether they have any connection with week days, since Rāhu and Ketu were also mentioned in the end. This is the Hindu concept of *navagraha* (nine grahas). Āryabhaṭa (499 A.D.) in *Kālakriyāpāda*[46a] mentions the 24 hours of the day and also the same rule similar to the Latin writer Firmicus Maternus (334 to 354 A.D.) and the Greek writer Pavlus Alexandriners (378 A.D.) in relation to the hours and their ruling planets, namely Saturn, Jupiter, Mars, Sun, Venus, Mercury and Moon; beginning with Saturn which is the farthest from the Sun.[45] Whether by intention or coincidence, the Jewish system was followed, even though no logical conclusion could be added for linking any particular planet with any particular day or any part of the day.

Since, the Hindu astrological order of the planets start with

Sun followed by Moon, Mars, Mercury, Jupiter, Venus and Saturn, the Hindu calendar also follows the same order, which fits in with the Jewish system also.

The earliest known genuine instance of the use of the planetary name of a day in India is in 484 A.D. found in the Eran Inscription[47] of Budhagupta from the Saugar district, which mentions the date as the (Gupta) year 165 on the twelfth *tithi* of the *śuklapakṣa* of *Āṣaḍa* and *Suragurordivasa*. The term *Suraguru* applies to *Bṛhaspati*, the preceptor of the gods (Jupiter). The next instance is found in a copper plate grant of the eastern Cālukya King Viṣṇuvardhana II, from Nellore District.[48]

Whether the week days were the outcome of the Western influence or a legacy from Syria, it has to be accepted, that they did not originate from India. But some how, the days of the week have been interpreted by Hindu astrologers as auspicious and inauspicious. In this also, no doubt, they are carried away by the Babylonian superstitious beliefs, along with their ingenuity of naming each day after a God. This led to the beliefs that the planets, representing Gods, rule the human destiny and let in a flood of astrological superstitions from China and India in the East and Roman Empire in the West. Even the iconoclastic Arabs appeared to have had great faith in astrology. Leaving aside the astrological factor, the week days have played part in determining the chronological investigations. The very first reference where the week day has played part, is in connection with fixing the dates of the Last Supper and crucifixion of Christ. By means of the week days occurring in the Gospel narratives of the New Testament, it is ascertained that these events must have happened in one of the three years namely 29 A.D., 30 A.D. or 33 A.D., although it will always remain a disputed point in which of the three years these events really happened.[49]

By the same way, though the seven-day week became a tool for inventing myths by the astrologers, it became a problem, when religious festivals had to be calculated. Hence, the major religious festivals could not be disturbed, but they continued to be adjusted to season by the use of intercalary months.

Determined efforts have been made to get rid of the seven-day week and the superstitition grown around it. The makers of French revolution introduced a ten-day week (decade) like the Egyptians three thousand years earlier. The Bolsheviks experimented with a five-day week and a six-day week and ultimately returned to the seven-day week. The ancient Iranians had no week days, but named the days of the month after a god, e.g., day of Ahura Mazda, day of Mithra, etc. Later on they also adopted the seven-day week.

At present the seven-day week is accepted by all, except some Jewish Rabbis. The introduction of an extra day at the end of each year or two extra days during each leap year, which belong to no week, is considered as a sacrilege by them.[44]

Fortnight (*pakṣa*) comprises 15 days or half a month. *Pakṣa* is entirely based on the Moon's revolution. The dark half (*kṛṣnapakṣa*) ends with the new moon (*amāvasyā*) and the bright half (*śuklapakṣa*) ends with the full moon (*pournamāsa*). Special names are given to the fortnights in *Taittriya Brāhmaṇa* namely *Pavitram, Pavayiṣyan, Pūtaḥ, Medhyah, Yaśah, Yaśasvān, Āyuḥ, Amṛtaḥ. Jīvaḥ, Svargaḥ. Lokaḥ, Sahasvān, Sahīyan, Ojasvan, Sahamāna, Janayan, Abhijayan, Sudraviṇaḥ, Dravinodaḥ, Ardra-pavitraḥ, Harikeśaḥ, Modaḥ* and *Promodaḥ*.

In this connection, reference may be made to about a fortnight of 13 days. In *Mahābhārata*, Vyāsa during his conversation with Dhritrāṣṭra seems to have told that he has known fortnights with 14, 15 and 16 days but never of one consisting of 13 days, which occurs once in 1000 years and since such one has occurred at that time there would be a great onslaught. Later works *Muhūrta Gaṇapati* and *Muhūrta Cintāmaṇi* also refer to the occurrence of lunar fortnight of 13 days.[51]

There is a lot of controversy on this statement. According to Dr M.N. Saha the full moon cannot fall on the thirteenth day after the new moon, probably the observers occasionally used to miss the first day of appearance of the thin crescent after full moon, due to the moon's nearness to the Sun or some other reason. The Moon is generally invisible for two or three nights round about new moon, and this was probably

the origin of widespread mourning for three nights.[44] Swamikkannu Pillai asserts that the fortnight of 13 days occur periodically. Accordingly to him it has occurred in 1805, 1813, 1830, 1847, 1849, 1861, etc., and the statement that the fortnight of 13 days occur once in 1000 days is not correct.[52] According to Swamikkannu Pillai the lunar fortnight of 13 days occurred on July 14th and August 24th in 1914; when the great war broke out.

This controversy is similar to the Id moon or crescent, which is sometimes visible on the second day and sometimes on the third. The visibility may also differ in different places. If the Moon is sighted on the third day, obviously, one day in a fortnight will be counted less.

Month is a natural division of time unlike the week. There are two types of months namely solar and lunar.

As has already been stated, according to ancient astronomers earth was considered to be at the centre and stationary while the Sun was revolving around it. They divided the circle of the Sun's path into 12 zodiacal signs each of 30° arc. The time required for the Sun to pass completely from one sign to another, or the time during which the Sun remained in one sign, constituted the solar month or *saura māsa.*

Lunar month is the time of one lunation. The moon actually traverses the sky, that is, starting from one point and returns to the same point in about 27⅓ days but since the Sun moves in the same direction it takes a little longer time to reach the Sun length, which makes it 29.5 days as the length of the lunar month. The month either starts with the full moon (*purnimānta*) or new moon (*āmanta*). The Greek, the Roman and the Jewish months started with the new moon.

The phases of the Moon is very important for the fishermen and the hunters. Moreover, the full cycle of the Moon coincide with menstrual cycle of women, which was deemed to be of great significance by the primitive tribes.

Islamic countries followed the Babylonian system of reckoning days by the Moon and the first day of the month started from the evening of the appearance of the thin crescent of the Moon in the western horizon after the new moon and the successive days are known as the second, third day of the

Moon.

A month of 30 days and a year of 12 months was generally accepted by most of the ancient countries. The term *māsa* is repeatedly mentioned in *Ṛg Veda.*[53] In Vedic literature, both *āmanta* as well as *purnimānta* systems of reckoning are mentioned. In *Taittrīya Brāhmaṇa*[54], along with the names of half months (fortnight), the following 13 names of the months are also mentioned (one *adhimāsa* or the extra month).

Aruṇaḥ, Arunarajaḥ, Puṇḍarīkaḥ, Viśvajīt, Abhijit, Ārdrah, Pinamāna, Unnavān, Rasavān Irāvān, Sarnoṣadaḥ, Sambharaḥ and *Mahasvān* (13th month).

The names of the months according to *Ṛg Veda* and Jaina calendar are as follows:

TABLE II

Modern names	*Ṛg Vedic names*	*Jaina names*	*English names*
1. Śravaṇa	Nabhās	Abhinanda	July-August
2. Bhādrapada	Nabhāsya	Supratiṣṭa	August-September
3. Asvāyuja	Iṣa	Vijaya	September-October
4. Kārtika	Urja	Prithivardhana	October-November
5. Mārgaśira	Sahas	Śreyan	Nov-December
6. Pauṣa	Sahasya	Śiva	December-January
7. Māgha	Tapas	Śiśira	January-February
8. Phālguna	Tapasyā	Haimavān	February-March
9. Caitra	Madhu	Vasanta	March-April
10. Vaiśākha	Mādhava	Kusumasambhava	April-May
11. Jyeṣṭha	Śukra	Nidāga	May-June
12. Āṣāḍa	Śuci	Vanavirodhi	June-July[55]

The names of the month later on were derived from the lunar asterisms. In this, the months were generally named according to the constellations in which the full moon appears. As for example, the month in which the full moon appears in the Asterism Citra (spica or virginis) is Caitra.

The names of the solar months, however, were borrowed from the names of the zodiacal constellations in which the Sun was situated, as it is observed in Kerala State. It is in vogue in Southern almanacs even today. It is difficult to State the date, when this adjustment of the months to *nakṣatras*

took place. These names are frequently mentioned by Manu. The Sanskrit names of the zodiacal signs are as follows:

Meṣa (Aries), *Riṣabha* (Taurus), *Mithuna* (Gemini), *Karkaṭa* (Cancer), *Simha* (Leo), *Kanyā* (Virgo), *Tulā* (Libra), *Vriśchika* (Scorpio), *Dhanus* (Sagittarius), *Makara* (Capricorn), *Kumbha* (Aquarius), and *Mīna* (Pisces).

It is to be noted that since the orbit of the earth is eliptical, all the solar months are not of same duration, but vary from 29 to 32 days. Because of the inequality and the difference in duration between solar and lunar months, sometimes two lunar months may begin in a solar month. In that case both the lunar months are called by the same name, the first being the intercalary (*aḍhika*) and the second as natural (*nija*). A more definite rule is that the lunar month in which no *sankrānti* occurs is called *aḍhika* and bears the same name as that of the next lunar month which is called *nija* or *śuddha* or *prākrīta* to distinguish from the intercalary month. The latter is the month in which adjustments are made. Less frequently, two solar months occur in the same lunar month. In that case there will be a lack of one lunar month corresponding to the second *sankrānti* that is one month suppressed (*kṣaya māsa*).

Solar months are observed in Tamiḻnāḍu, Kerala, Bengal and Punjab. Mostly other states follow lunar calendar.

The *panchāngas* based on *Sūryasiddhānta* (9th century A.D.) vary slightly in different places. One lunar month generally ends and the next begins during the course of the solar month. The solar month taken as the current civil month received the name of the first lunar month as in Tamiḻ country but in Bengal and Punjab, the name of the second. Therefore, the successive *Citirai* and *Vaikāsi* in Tamiḻnāḍu, and *Meḍam* and *Eḍavam* in Kerala will be called *Baiśakho* and *Jyoiṣṭho* in Bengal and *Baisākhi* and *Jyeṣṭha* in Punjab.

Moreover, when the days are stated in the present Gregorian calendar, the dates will not be the same in every year. *Meśa sankrānti* which was on March 16 on 400 A.D., was on March 27 in 1700 A.D., and was on April 13 in 1976 A.D. By the same way the date of Diwali does not fall on the same date in all the years.

Seasons (*ṛtu*) which are natural phenomena have been classified differently in different nations. Egyptians calculated their seasons in relation to the annual flooding of the Nile, which had been the most important feature in their civilization. Between succeessive risings of the water, the Egyptians designated three seasons; the season of the inundation, the season of the sowing and the season of the harvest. These natural happenings were associated with the heliacal rising of the dog star, *Sirius*, the brightest star they saw in the sky.

In European countries the four seasons, summer, spring, autumn and winter were in vogue. This classification is in relation to the weather conditions occurring due to the regular cycle of the summer and winter solistice and the autumn and the vernal equinox.

In ancient India the season can be traced from *Ṛg Vedic* period. The term *cāturmāsya* or four-monthly denotes the festival of the Vedic ritual held at the beginning of the three seasons of four months each, into which the Vedic year was divided. The Vedic sacrifices commenced with the beginning of each season. *Vaiśvadeva* coincided with *Phālguni* full moon, the second *Varuṇa praghāśas* coincided with the *Āṣāḍa* full moon and the third *Śākamedha* with the *Kārttiki* full moon. There were, however, alternate datings. The festival can also be held at *Caitri*, *Śrāvaṇi* and *Agrahāyani* full moon. The first mentioned *Vaiśvadeva* sacrifice must be the starting of the summer followed by spring; the second *Varunapraghāśas*, as the name suggests relates to the rainy season and the third *Śākamedha* the winter season. This division of three seasons are enumerated in the *Brāhmana* literature also.[56]

In one passage of the *Ṛg Veda* the terms *vasanta* (spring) *grīṣma* (summer) and *śarad* (autumn) are given. In another passage five seasons namely *vasanta*, *grīṣma*, *varṣā*, *śarad* and *hemanta* and *śiśira* are mentioned. In the *Brāhmaṇa* literature *hemanta* and *śiśira* have been divided and thus six seasons are mentioned. This six-fold divisions may be a later development after the *Ṛg Vedic* period, for use in the agricultural operations.

The names of the seasons differ in *Taittrīya samhita* and *Śatapatha Brāhmaṇa*.[57]

TABLE III

Seasons	*Taittriya Samhita*	*Śatapatha Brāhmaṇa*
Vasanta (spring)	Mādhu and Mādhava	Rathagriṣṭa and Rathanjaia
Grīṣma (summer)	Śukra and Śuci	Rathasvena and Rathacitra
Varṣā (Rainy)	Nābhās and Nabhāsya	Rathaprata and Asamartha
Śarad (Autumn)	Iṣa and Urja	Tarkeya and Ariṣṭanemi
Hemanta (Winter)	Sahaṣ and Sahāsya	Senajit and Susena
Śiśira (cool months)	Tapas and Tapasyā	Tapas and Tapasyā

The Jaina calendar[55] mentions five seasons namely rains, autumn, dewy, spring and summer, the seasons commencing with *Asāḍa*. It will not be out of place to mention here that Kauṭilya also referred to the year beginning with the summer solistice at the end of *Āsāḍa*. Perhaps, since the year commenced with the rainy season, the name *varṣa* has been acquired for the year. Buddhist calendar refers to three seasons, namely, *hemanta*, *grīṣma* and *varṣā*.[58]

Ayaṇa (the period of 6 months) stands for just one half of a year. There are two *ayaṇas* namely *Uttarāyaṇa* and *Dakṣiṇāyaṇa*. They refer to the north-ward and south-ward courses respectively of the Sun. According to *Vedānga Jyotiṣa*, *Uttarāyaṇa* (sun's northern phase) takes place when Sun and Moon join in *Dhaniṣṭa* (Delphinus) at the beginning of *Māgha*, while *Dakṣināyaṇa* in the month of *Śrāvaṇa* at the half of *Āśleṣā*.[59] Kauṭilya[60] has also recorded the traditional occurrence of the *ayaṇas* in *Āśleṣā* and *Śrāvaṇa*. These two days denote the winter and summer solstices.

Samvatsara or *year*: most of the countries considered the year to consist of 360 days, divided into 12 months in ancient days. This was on the basis of 12 full periods of the moon, which is roughly 30 days. Egyptians have preserved a story of how they found out the mistake and rectified it into 365 days. The year continued to be 360 days and the last 5 days were supposed to be the birth days of gods, born out of illicit union between *Seb* and *Nut* namely *Orius*, *Iris*, *Nephthys*, *Set* and *Arulis*, five chief gods of the Egyptian pantheon. Ancient Egyptians noticed that 365 days cannot be the exact length of

the year, since the heliacal rising of the bright star *Sirius* and the arrival of the annual flood of Nile at the Egyptian capital did not coincide. The bright star *Sirius*, which stood for the Egyptian goddess *Isis* and was carefully observed for ritualistic purposes by the priests who noted down that the Sun returned to the same point, not after intervals of 365 days, but only after 365¼ days. The Egyptian priests kept this knowledge only to themselves for a long period, so that it enabled them to predict the date of the annual flood and maintained their influence and hold on the public. The attempts made by Ptolemies (320 B.C.-40 B.C.) to reform the calendar was opposed by the priests. Later Julius Caesar reformed the calendar which is nearly the modern Gregorian calendar, with leap year occurring every fourth year.

The Aztecs had a completely different duration for the year. The Maya people, who lived in southern Honduras, Guatemala and Yucatan dwelt on great vistas of time. The calendar of the Aztecs or Maya people was based on a different type of calculation. The Maya calendar year consisted of 260 days, 20 day names attached to the numbers 1 to 13 both reentering cycles, which ran concurrently. Since there are 20 names and only 13 numbers, the number attached to any name increases by 7 at each recurrence, while 13 is deducted, if the total exceeds the number.[61]

The 260-day sequence or *Tonalpolhualli*, perhaps, might be the primitive calculation of the period of gestation, that is, the period from conception to birth. This indeed must be analogous to the Indian concept of the period of pregnancy to 10 months, in which the periodic month must be 27 days or *nakṣatra māsa*. For keeping count of the seasons there was a year of 365 days composed of 18 months of 20 days each, with an extra 5 days at the end of the year. These five days formed a period of extreme misfortune called "Uayeb" and other names descriptive of their dire nature.

Solar as well as lunar years are mentioned by Vedic seers. The early astronomers in India divided the Sun's path into twelve zodiacal signs each of 30° arc. The Sun, passing in its annual course, starting from the first sign *Meṣa* (*Aries*), enters and leaves in turn each of the twelve signs, thereby completing

the circle of 360°. This complete circle is associated with the revolution of earth around the Sun. This they considered as 360 days and has been so recorded in the *Ṛg Veda.*

In *Sāmaveda sūtras* different types of months and years are mentioned. They refer to (1) years with 324 days, i.e., periodic years with 12 months of 27 days each, (2) years with 351 days, i.e., periodic years with 12 months of 27 days each, plus another month of 27 days, (3) years with 354 days, six months of 30 days, and six months with 29 days (in other words lunar cynodic years), (4) years with 360 days (ordinary civil [sāvana] years), (5) years with 378 days which is Thibault clearly shows, are third years, in which after two years of 360 days, 18 days were added to bring about correspondence between civil and solar years of 366 days. Years of 366 days were mentioned in *Vedānga Jyotiṣa* and by Garga.[62]

The insufficiency of the lunar year is apparent from the passages in *Taittrīya Samhita*[63] and *Śatapatha Brāhmaṇa*[64], where the chaos in sowing and reaping was dealt with.

Hence the ancients regarded the year as 360 days (lunar year) which is less than the tropical year by $5\frac{1}{4}$ days. The difference in six years will be $31\frac{1}{2}$ days. So every sixth year one month is intercalated to make up for the difference. This intercalated month is termed as *udvatsara, śaniśrasa* (slippery), *samsarpa, malimula* or *malimulu.* At present this is known as *adhimāsa* (extra month) or *mala māsa* (unclean month).

The Jaina works *Sūryaprajñāpti* and *Kālalokaprakāśa*[65] refer to four types of years.

1. *Nakṣatra samvatsara*
2. *Yuga Samvatsara* (cyclic year of 60 lunar months)
3. *Pramāṇa samvatsara*
4. *Śani samvatsara*

Nakṣatra samvatsara (sidereal year) is of 12 kinds as *Śrāvaṇa Bhādrapada*, etc. When Jupiter completes the whole circle of constellations once, it is called a *nakṣatra samvatsara* of 12 years. This is calculated as 12 *nakṣatramāsas* $=12\times27\frac{21}{67}$ days $=327$ days $+\frac{51}{67}$ day.

Yuga Samvatsara consist of 60 lunar months plus two intercalary months. This can be calculated as follows:

Lunar year $=29\frac{16}{31}\times12=354$ days $+\frac{6}{31}$ days.

Intercalary lunar year $=12\times30\frac{1}{2}=366$ days. Once in 30 solar months there will be one intercalary month.

Pramāṇa samvatsara is of five kinds namely *nakṣatra* (sidereal) *ṛtu* (seasonal), *Candra* (lunar) *Āditya* (solar) and intercalary lunar years.

Nakṣatra and lunar years have already been explained above. *Ṛtu samvatsara* is of 360 days and is also called *karma* (work) and *sāvana* (engagement) *samvatsara.* Solar year is of 366 days consisting of 12 months of $30\frac{1}{2}$ days.

According to this the following calculations can be made:

Solar year	366 days	Solar month	$30\frac{1}{2}$ days
Ṛtu, Karma or *Sāvana* year	360 days	*Kārma* month	30 days
The lunar year	$354\frac{6}{31}$ days	Lunar month	$29\frac{16}{31}$ days
Nakṣatra year	$327\frac{51}{67}$ days	*Nakṣatra* month	$27\frac{21}{67}$ days
Intercalary	$383\frac{44}{62}$ days	Intercalary lunar month	$31\frac{121}{124}$ days

Thus in a yuga or cycle of 5 years (1830 days) there are 60 solar months or 61 *sāvana* months, or 62 lunar months of 67 *nakṣatra* months. The intercalary months are considered for the adjustment in the total number of days. Leaving aside these calculations, the different types of years which were in use can be summed up as follows.

1. *Civil year* of 360 days of 12 months which was most common. An intercalary month was added every sixth year. It is still in vogue in most of the almanacs.

2. *Sidereal year*: Āryabhaṭa,[66], Brahmagupta[67] and Bhāskara[68] calculated the year from the heliacal rising of a bright star at the intervals of 365 and 366 days. They observed that the selfsame stars returned year after year at the same time and place and the path of the Sun and Moon amongst them could be followed. The heliacal rising of a *nakṣatra* is its first visible rising after its conjunction with the Sun, that is, when it is at sufficient distance from the Sun to be seen on the horizon, at its rising in the morning before Sun rise, or at its rising in the evening after sunset. This is termed as sidereal year (sider-star) or astral year. The *Nirāyaṇa* Hindu almanac follows the system.

3. *The solar year* of the one complete revolution of the earth around the Sun starts with *Sankrānti* and not with full

moon or new moon. Generally, it starts with *Mesa Sankranti* in the month of *Caitra*. Purely solar reckoning is adopted in Bengal, Punjab, Tamilnāḍu and Kerala.

4. *The luni-solar year* is the year which begins with the first *tithi* of the bright half of *Caitra*. Here the year begins with the new moon after *Mīna Sankrānti*, except when *Caitra* is an intercalary month. This is observed as *Yugādhi* in Karṇāṭakạ and Andhra and *Guḍīpāḍva* in Mahārāṣṭra at present. This date falls generally in March. It may be noted that the earliest Roman calendar, which contained 10 months comprising of 304 days started with the first of March.

The twelve-year cycle of Jupiter: This is the time taken by Jupiter to make a complete circle around the Sun. The names of the *samvatsaras* or years are determind in two different ways. It has been stated by Varāhamihira, "with whatever *nakṣatra* (Jupiter) the counsellor of Indra, the lord of the gods attains (his) rising, the year is to be spoken of (as) having the application of that (*nakṣatra*), in accordance with the order of the month". Here the term rising indicates the heliacal rising. Jupiter becomes invisible for some days in the western horizon, before and after his conjuction with the Sun, that is when the Jupiter comes nearer the Sun. It is then said to be resting. This state of invisibility remains for a period of twentyfive to thirtyone days. After this when Jupiter becomes visible in the east, he is said to rise.[71].

Varāhamihira gives the names of twelve-year cycle starting with *Kārtika*. The names are given to the *samvatsaras*, according to the particular *naksatras*, in which the heliacal rising takes place. Of the twentyseven *naksatras*, two are assigned to each of nine of the twelve months and three to each of the remaining three months. The names of the lunar months are used as the names of the *samvatsaras* of the twelve-year cycle of Jupiter.

Twelve-year cycle of Jupiter is now determined by the mean sign system, with the aid of mean longitude of a heavenly body which is the longitude of an imaginary body of the same name, conceived to move uniformly with the mean motion of the real body.

TABLE IV

Registration of the names of the *samvatsaras* from *nakṣatras*

Name of grouping of naksatras	*Name of the months allotted to samvatsaras*
Krittikā, Rohiṇi	*Kārttika*
Mṛiga, Ārdra	*Mārgaśīrsa*
Punarvasu, Pusyā	*Pausa*
Āslesā, Maghā	*Māgha*
Pūrvaphālgunī, Uttraphālgunī, Hasta	*Phālguna*
Citra, Swāti	*Caitra*
Viśākha, Anūrādha	*Vaiśākha*
Jyeṣṭha, Mūla	*Jyeṣtha*
Purvāsāḍha, Uttarāsāḍha (Abhijit)	*Āsāḍha*
Śrāvaṇa, Dhanisṭha	*Śrāvaṇa*
Satatāraka, Pūrva Bhādrapada, Uttara Bhādrapada	*Bhādrapada*
Revati, Aświni, Bharaṇī	*Āświna* (*Asvāyuja*)

Āryabhaṭa in his *Āryabhaṭīya*, in *Kālakriyāpāda* states, "the revolutions of Jupiter, multiplied by the signs (12 *raśi*) are the years of Jupiter, the first of which is Aśvāyuja". Brahmagupta in *Brahmasphuta siddhānta*[73] also puts this in similar words. In this system, the signs are intended to be according to Jupiter's mean longitude. Suppose that on a certain day Jupiter's mean longitude is 10 signs and 12 degrees, then he is in the 11th sign. Then, counting from *Aśvāyuja*, we have *Śrāvaṇa* as the current *samvatsara*.

The usage of this cycle of twelve years is now very rare. It is almost unknown to people in many parts of India. Heliacal rising and setting is mentioned only in almanacs for religious purposes. When Jupiter is invisible some duties and ceremonies such as marriage, pilgrimage, etc., are to be avoided. Hence the dates of his resting periods are considered necessary, in order to fix the auspicious times for such occasions.

The cycle of twelve animals (one animal per year) is common from Turkestan to Japan which is as follows; rat, ox, tiger, hare, dragon, serpent, horse, goat, monkey, cock, dog

and bear. Its relationship to Jupiter cycle is not clear.

The Mayans observed a cycle of 13,515 days, comprising 52 ritual years of 260 days each. The Indians, however, followed a 60-year cycle (5 Jupiter cycles).

Jupiter cycle af sixty years: In this reckoning each calendar year received a name from a given list of sixty names which is as follows:

1. *Prabhava*
2. *Vibhava*
3. *Śukla*
4. *Pramoda*
5. *Prajāpati*
6. *Aṅgīrasa*
7. *Śrīmukha*
8. *Bhava*
9. *Yuyan*
10. *Dhātri*
11. *Īśwara*
12. *Bahudhānya*
13. *Pramāthin*
14. *Vikrama*
15. *Vṛṣa*
16. *Citrabhānu*
17. *Subhānu*
18. *Tāraṇa*
19. *Pārthiva*
20. *Vyaya*
21. *Sarvajit*
22. *Sarvadhārin*
23. *Virodhin*
24. *Vikṛta*
25. *Khara*
26. *Nandana*
27. *Vijaya*
28. *Jaya*
29. *Manmatha*
30. *Durmukha*
31. *Hemalambha*
32. *Vilambin*
33. *Vikārin*
34. *Śārvarin*
35. *Plava*
36. *Śubhakṛt*
37. *Śobhakaraṇa*
38. *Krodhin*
39. *Viśvāvasu*
40. *Parābhava*
41. *Plavaṅga*
42. *Kīlaka*
43. *Saumya*
44. *Sādhāraṇa*
45. *Virodhikṛt*
46. *Paridhāvin*
47. *Pramādin*
48. *Ānanda*
49. *Rākṣasa*
50. *Anala* or *Nala*
51. *Piṅgala*
52. *Kālayukta*
53. *Siddhārthin*
54. *Raudra*
55. *Durmati*
56. *Dundubhi*
57. *Rudirodgarin*
58. *Raktāksa*
59. *Krodhana*
60. *Kṣaya* or *Akṣaya*

Āryabhaṭa and Brahmagupta gave no rule for finding the *samvatsaras* of the sixty-year cycle. Only in *Bṛhatsamhita* and

Sūryasiddhānta the sixty year cycle is mentioned. The former starts with *Prabhava*, while the latter work starts with the year *Vijaya* as the first of the series.

The years of Jupiter or Jovian cycle of sixty years, were classified by Varāhamihira into twelve *yugas* of five years each, the *yugas* being known after their respective presiding divinities, namely (1) Viṣṇu (2) Surejya (Bṛhaspati) (3) Bālabhid (Indra) (4) Mutaśa (Agni) (5) Traṣṭa, (6) Ahirbudhaya (7) Potr (Mars) (8) Viśvadeva (9) Soma (Moon) (10) Śakrānala (Indrāgni) (11) Aświn and (12) Bhaga. The five years of *yugas* are known as (1) Samvatsara (2) Parivatsara (3) Idavatsara (4) Vatsara and (5) Idvatsara.[76]

Calculation of Jovian year seems to differ from each and every Hindu authorities. Most of the writers, however, conclude that, the duration of the Jovian year to be 361.02 years of 361 days and 30 minutes, which is roughly 4 days less than the sidereal year.

The Jovian calendar or *Bārhsapatya samvatsara* as consisting of 12 years is at present a misnomer for the following reason. If heliacal rising is considered as the basis for the Jovian calendar, since the interval between two risings is generally 399 days, in twelve sidereal years there will be only eleven *Bārhaspatya* years, that is, there will be only eleven conjunctions of the Sun and Jupiter. Hence in a cycle of twelve Jovian years, there will be only eleven conjunctions instead of twelve. Similarly when we consider the sixty year cycle, since there are roughly four days difference between luni-solar calendar, and the Jovian calendar, in every 85 or 86 years one year will have to be expunged or suppressed. Expunction means, the omission to give the *samvatsara* its name, so that it does not affect the duration of the cycle. The general rule is that, the name of the *samvatsara* current in *Meṣa Sānkrānti* of any year is attached to the whole year, not withstanding the fact, that another *samvatsara* may have begun before its close. As for example when the 9th *samvatsara*, *Yuvan*, is current in *Meṣa Sankrānti*, but ends two months later when the 10th *samvatsara* should begin, still the whole year will be considered only as *Yuvan*.

In this there is a difference in northern and southern

reckoning subsequent to 900 A.D. Prior to 900 A.D. as can be seen from the grant of Rāṣṭrakūṭa King Govinda III[78], both in the north and south the expunction was followed. The grant was issued on the bright fortnight of Vaiśāka of the year *Subhānu* (corresponding to 804 A.D.). This has taken into account the expunction. The Anumkoṇḍa inscription[79] of the Kākatīya King Rudradeva dated as Śaka 16 *Citrabhanu*, which corresponds to 19th January 1163, does not take expunction into account, since on the northern reckoning it should have been *Vijaya* and not *Citrabhānu*.

From the examination of the epigraphical records chronologically, the following facts emerge. The names of the years according to Jupiter's sixty year cycle, are only occasionally met within the of Northern India, while they are very common in South India. The use of 12 year cycle is found in seven inscriptions so far; five records of the Mahārājas Hastin and Samśobha and two grants of Kaḍamba chieftain Mrigeśavarman. The earliest inscriptions to record the year according to the sixty year cycle [are from Nāgārjunakoṇḍa.[80] Records at the time of the Ikṣvāku King Vīrapuruṣa Datta (second half of the 3rd century A.D.) and another of his son Ehuvula Sāntamula (close of the 3rd and early part of 4th century A.D.) refer to samvatsara *Vijaya*. The date of the former corresponds to 273 A.D., while the latter to 333 A.D. The next is in the Mahākūṭa pillar inscription[81] of Cālukya Mangaleśa (597-610 A.D.) of Badāmi, dated in the year Siddhārtha (Siddhārthin).

It will be interesting to note that the Chinese history and the annals of the Chinese emperors, were written with reference to cycles of 60 years. 60 year cycle was in use in Chaldea under the name of Sosos. Cycles of 600 years called Neros and another 3600 of years were also in vogue in Chaldea.

Yuga as a cycle was mentioned as early as in *Ṛg Veda*.[82] The expression '*daśame yuga*' applied to Dīrghatamas in one passage in *Ṛg Veda*, is translated by Wilson, as a lustrum of five years, whereas in the Vedic Index it is given as tenth decade. In *Ṛg Veda*, *yuga* appears to have had different meanings. It refers to a short period as well as long periods of time.

The cycle of four *yugas*, *kali*, *sayana*, *treta* and *kṛta* as a cycle of *yuga* occurs first in *Brāhmaṇa* literature. In *Yajur Veda* the terms *samvatsara*, *parivatsara*, *idavatsara*, *idvatsara* and *vatsara* occur. It is not clear, whether these constitute a *yuga* or years. In *Vedānga jyotisa* it is clearly stated that a cycle of five years constitute a *yuga*.[83] According to this work, the cycle starts with the bright fortnight of the month of *Māgha* and ends with dark fortnight of *Pausa*.

Later on each *yuga* seems to have developed into a very big unit of time with several years. Āryabhaṭa considers *kṛta*, *treta*, *dvapara* and *kali* having equal number of years, which is 1,080,000 years and the total *yuga* or *mahāyuga* to be of 4,320,000 years. In Varāhamihira's *Pañcasiddhāntika* and in *purāṇas*[84] the duration of each *yuga* vary considerably.

In Varāhamihira's *Romaka siddhānta*[85] in the *Pañcasiddhāntika* a *yuga* is said to comprise 2850 years, while in *Sūryasiddhānta*[86] it is said to be of 4,320,000 years.

According to Brahmagupta[88], *kṛtayuga* consist of 1,728,000 years. *Tretā* of 1,296,000 years, *dvāpara* of 864,000 years, and *kaliyuga* of 432,000 years and the total being 4,320,000 years. This coincides with the Puranic idea of the *yugas*[89] calculated in the order of 4:3:2:1 on the total number of years.

Manvantara according to Brahmagupta and *Purāṇas* is a period consisting of 71 repetitions of four *yugas*, while Āryabhaṭa considers a *manvantara* to be of 72 repetitions of the four *yugas*. In the beginning of *kṛta*, there is a *sandhya* or junction of 14,4000 years. In the beginning and at the close of *treta*, there is a junction of 108,000 years and similarly in the beginning and at the close of *dvāpara* there is a junction of 72,0000 years, while at the beginning and close of *kali* 36,000 years. The present *manvantara* is called *Vaivasvata*, after the patriarch of the *manvantara Vivasvān*.[89]

Kalpa is considered to be the day time, of one day of the God Brahman. 14 *manvataras* plus the junction periods is said to constitute a *kalpa*, according to Purāṇas and Brahmagupta.[90] In the beginning and at the close of each *manvantara* there are *sandhis* or junctions, each equal to the measure of *kṛta*. Thus, one *kalpa* will be equal to (71×14) *yugas* $+15$ *sandhis* $=$

994 *yugas* $+ 15 \times 1.728{,}000$ years $= 994$ *yugas* $+ \frac{15 \times 1{,}728{,}000}{4{,}320{,}000}$ *yugas* $= 994$ *yugas* $+ 6$ *yugas* $= 1000$ *yugas* = Brahma's day. Āryabhaṭa[91], however, considers a *kalpa* to be of 14×72 *yugas* which comes to 1008 *yugas.*

At the end of the day time of Brahma, everything is said to get destroyed and in the night, chaos prevail and is supposed to be followed by his starting the creation again. This process of creation and destruction is said to alternate during the life of a Brahma, which is called a *Mahākalpa* and is said to last for 100 years, each composed of 360 such days and nights. Then everything is supposed to be overwhelmed (*mahāpralaya*) by the final deluge, until another Brahma comes spontaneously into existence. Here again, Āryabhaṭa in *Kālakriyāpāda*[92] expressed that even Brahma cannot cover the whole span of universal time, since the time has no beginning nor end. The idea seems to be that a Brahma dies followed by another Brahma and so on as a continuous process.

Bhāskarācārya in *Siddhāntā śiromani*[93], also asserts a similar opinion starting that "since this same time had no beginning, I know not how many Brahmans have passed away".

According to Sūryasiddhānta we are said to be in the *kali yuga* of the twenty eighth *caturyuga* (cycle of four yugas), in the seventh *manvantara,* in the first *kalpa,* in the second half of the life of Brahmā. According to the calculation of *Sūryasiddhānta* we are still only in the dawn of *kali* age, which lasts for 36,000 years. The day time with all its deprived characteristics fully developed, will not begin until 32,890 A.D. This day time period will remain for 360,000 years followed by a twilight period of 36,000 years.[89]

This type of lengthy duration of an enormous period is also found in pre-historic China. Between 7 B.C. and 22 A.D. a treatise on the calendar, written by Lin Hein, the imperial librarian of whom Sarton[94] reports, refer to a period of 23,639,040 years.

The Greek and Roman[89] astronomers sought for a period, in which different planetary revolutions were completed. It is termed as exeligmos by Greeks and annus magnus or mundanus by the Romans. This represents a pariod of evolution and revolution, in the course of which, any given order of things run through an appointed course and is completed by returning to the state from which it started. They adopted exeligmos, beginning and ending with the conjunction of the Sun, Moon and the planets that corresponds to the first point of *Meṣa,* which conjunction of course involved a new moon and the vernal equinox.[95] This conjunction is also indicated by Āryabhaṭa in *Kālakriyāpāda,* The *yuga* (i.e. the *Mahāyu ga* or *caturyuga*) the month and the day began altogether at the beginning of the bright fortnight of *Caitra.*[96]

To sum up, time as a measure on dimension, is based on its relation to natural phenomena. The bigger units of time like the day, month, seasons and year are in relation to the rotation of the earth on its axis, causing the day and night; revolution of the Moon around the earth resulting in the concept of months and the revolution of the earth around the Sun leading to the sequence of seasons and calculation of the years.

In developing the smaller units of time, quite an ingenuity has been used by people in the past, particularly in the absence of the mechanical clocks as in modern times. The smaller units of time in ancient India like *paramāṇu, aṇu truṭi, tatpara,* etc., are impractical. The units like *guruvaksara, mātra,* etc., has greater usefulness for measure of meters in music than for calculation of time. These types of minute divisions are seen in the Jewish measurement of time also. They have divided their hour into 1080 parts or halequim, each haleq equalling 33 seconds. A haleq is further divided into 76 regaim. It is difficult to equate these minute divisions and correlate them with the units in other countries.

No doubt most of the time units are the legacy of the past, dividing the day by 24 hours and the hour into 60 minute and minute into 60 seconds which has its relations with the division of the zodiac into 360°. The Egyptians and the Jews had the day divided into 24 hours, while the Indians divided the day into 30 *muhūrtas* or 60 *nāḍikas,* with $2\frac{1}{2}$ *nāḍikas* making an hour. Even today the Hindu almanacs use the *nāḍikas* for calculations of time.

There are two systems relating to the calculations relating to a day, either as beginning at midnight or at the dawn

(*ardharātrika* or *audhāyika* systems). The Egyptians began their day at dawn, while Babylonians[97], Jews and Muslims calculated it from sunset to sunset.

The Indian day is calculated in the almanacs in relating to *tithis* and *nakṣatras*. A day is normally known as the day of the fortnight, for example, *prathamā*, *dwitīyā*, etc., or of any of the 27 *nakṣatras* like *Aświni*, *Bharaṇī* etc. The *tithi* or *nakṣatra*, which is identified with a day is that *tithi* or *nakṣatra* which was current at sunrise on the day in question.

Though the *tithi* or *nakṣatra* may have ended, the next minute after sunrise, and the next *tithi* or *nakṣatra* may have been current for the whole of the remaining day, it is the *tithi* or *nakṣatra* current at sunrise which gives its name to the day. Nevertheless, in numerous inscriptions, the *tithi* or *nakṣatra* quoted is not at which was current at sunrise on the day in question, but that which commenced at some part of the day and would be current at sunrise, only on the next day.[98]

At present in the almanacs, Indian time is kept in *ghaṭikas* ($\frac{1}{60}$ of a day or 24 minutes). Each *ghaṭika* (*nāḻigai* in Tāmiḻ) is divided into *palas* (Tamiḻ *vināḍi* or $\frac{1}{60}$ of a *ghaṭika* or 24 seconds). The day is not reckoned from midnight to midnight as in European calendar, but from sunrise to sunrise. Since there are as many *panchāngas* as the number of cities in India, the sunrise is not the same in all places. Hence, one central place is selected and with necessary corrections, it is applied to other places. The central latitude in Equator and central longitude is 75° 46′6″ East of Greenwich in which an imaginary island, Lanka in Indian ocean is taken into account. This Lanka has no connection with Śrī Lanka (Ceylon).[99]

The next unit of time, the week, which has been discussed in detail earlier is not of Indian origin but derived from Babylonian times. For verifying Indian dates the week day is very important. Indian dates is pronounced as often unverifiable, in the absence of week days. To 'verify' a date, is to show that it is equivalent to a particular day, month, year and almost all the details and that it would be inconsistent with any other day, during a certain number of years. For instance, a date such as Tuesday 10th *tithi* and *nakṣatra* *Ārdra* without reference to month, can be verified as a rule only for a period

of 3, 7 or 10 years, because at this period it will recur with same details. If the year is also cited, then all the details can be seen consistent with the given year and not with any other year for the next 3, 7 or 10 years. When a date is given merely with *tithi*, *nakṣatra* and year without a week day, it cannot be verified, because, in every year, a combination of such a *tithi* and *nakṣatra* is bound to recur. Hence the date and year cannot be free from error.[99]

For the Christians the week days are very important, since they wanted the Resurrection of Christ, to be placed on a Sunday. It is to be noted that nowhere in the Bible, the day of the crucifixion is mentioned. Christ was alleged to have been crucified on the Jewish festival of Passover, which is the first full moon after the vernal equinox.

The fortnight, which is a division of half of a month is the easiest to calculate. Moon as well as crescent, is easily visible without any mechanism and counting is easy. Month, which is generally a twelfth of a year, is counted from the movements of Sun and Moon. The word 'māsa' also means Moon. Another synonym for the moon is 'māsakṛt'. Similarly the English word month is derived from Moon. The passage in Psalms 18, 19 "He appointed the moon for seasons" indicate the basis for lunar months. The ancient astronomers also noted that the Moon moved from star to star and came back to the first star in 27 solar days. Since the Sun also moves in the same direction the *nakṣatra māsa* or sidereal month actually takes 29.5 days.

Another way of counting the Moon's phases, which is very easy and practical, is from new moon to new moon, or full moon to full moon, which is roughly 30 days. This system was followed by Babylonians and at present by Islamic countries. In India the exact length of the period is calculated as 29½ days. Actually the moment of new moon is the moment when Sun and Moon have the same longitude. That is, the same distance measured from a fixed point in the heavens. Various aspects of life and activities in the past were reckoned with the Moon. Hunting with the help of Moon was an aid to economic planning of the ancients. Nine Moons of pregnancy, six Moons between sowing and reaping were facts that were

important to everybody and were easily ascertained.

Solar month is a variable unit, which is the time taken by Sun in its motion over 30°, of the eliptic. The commencement of the solar month is termed *sankrānti*, that is the moment when the Sun enters a constellation of the zodiac Solar months vary from 29, 30 to 31 days. It is not necessary, that the days should be the same in all years. As for example, *Cittirai* (*caitra*) had ordinarily 31 days, but it also had only 30 days in certain years.

The solar calendar is described by some authors as luni-solar calendar, since the months are named after the zodiacal constellations, in which the Sun is situated.

Calculation of the commencement of lunar month is characterized with more certainty, since the moon's phases are patents and observable facts; whereas the course of the sun cannot be perceived. It is difficult to ascertain with certainty as to at which definite stage on a particular day the Sun is placed. Hence the astronomical commencement of a solar month varies, unlike the lunar month, where there is uniformity throughout. At present in Orissa, the solar month *Amli* or *Vilayati* eras begin on the day of the *sankrānti* irrespective of the moment it commences. In Bengal, when the *sankrānti* takes place between sunrise and midnight (or between 0 hrs. and 18 hrs. Lanka), the solar month begins on the next day. When it occurs after midnight (45 *ghaṭikas*), the solar month commences on the third day. In Tamilnāḍu, if the *sankrānti* takes place on any day before sunset (12 hrs. Lanka), that day is the first day. If *sankrānti* takes place after sunset (between 12 hours and 24 hours Lanka time), the next day is the first day. In Kerala the day between sunrise and sunset is divided into five equal parts. If the *sankrānti* falls within the first three parts, the month begins on the same day, otherwise on the following day.[100] Even in these, the opinions differ a lot, among the astronomers of the past and present.

Seasons are important factors in determining the year. The simplest of all types of time reckoning is by correlating between synchronous natural events. For example, from the blooming of certain plants and the appearance of birds, the on coming rain can be forecasted. In Egypt, flooding of the Nile,

was an important factor in predicting the seasons.

Most of the activities of the primitive men were dependent on seasons. Agriculturists followed the seasons for sowing and harvest. Hunters and fishermen, relied on the seasons to assess the seasonal migration of animals and fish.

In ancient India, the years starting with *Madhu* and *Mādhava* were later replaced by *Caitra* and *Vaiśākha*. *Caitra* and *Vaiśākha* were described as spring month in *Mahābhārata*.[101]

Later on *Phālguna* and *Caitra* were considered as spring months.[102] This is due to the solar or lunar years being not reconciled with the tropical year. The solar year is longer by 0.0165 days than the tropical year. Hence in 1800 years, the seasons will fall back by a month and this is what had happened in the calculations of the years.

The next and most diversified astronomical constant is the year. The earliest divisions of the year must have been based on the seasons. The first month of the year appears to have been based on certain astronomical sequences, but later on some important event like the foundation of a new city, as in the case of Rome or with the movement of people from one area to another as in Israel or with some religious significance. These also coincided with certain cardinal points in the year. To give a few examples Mosaic law has enacted that Abib, the month in which the Israelites came out of Egypt, was to be observed as the first month of the year. It was in this month the feast of Passover was celebrated and that green ears of corn were brought to the priests as the first fruits of the harvest. The earliest ripening of barley in Palestine was in April, with the first month of the year starting at about the time of vernal equinox (April 22nd). After the captivity of the Israelites, the names of the months were changed, the first being *Nisan*. In order to keep the first month at the correct position, thirteenth month was intercalated.

The earliest Roman calendar started in March containing ten months comprising 304 days. Greeks had the year first divided into three seasons, spring, summer and winter and later on autumn was added. Winter began with the heliacal setting of the Pleiadas and ended with vernal equinox. Spring

continued until the heliacal rising of *Pleiadas*; summer until the heliacal rising of *Arcturus* and autumn occupied the remainder of the year, until and next heliacal setting of *Pleiadas*.[103] This also coincided with the four cardinal points, namely the two solstices and two equinoxes. The coldest and the longest night is 22nd and 23rd of December, which is the winter solstice and the hottest and the longest day is 21st or 22nd June which is the summer solstice. These are the times when the Sun is farthest from. Equator. 20th or 21st March and 22nd or 23rd September are the days, when the day and night are equal since the Sun crosses the Equator on these days.

The Hindus had the idea of tropical year, that is the year which brings the seasons round at the same time of the year as given in *Vedānga jyotiṣa*. In *Vedānga jyotiṣa*, *Daksināyana* is counted from half of *Aśleṣa* (113° *Hydrai*), while *Uttarāyana* is counted from the beginning of *Dhaniṣṭha* (290° *Delphin*) in the month of *Māgha*. According to Varāhamihira, *Daksināyana* occurred in *Punarvasū* in (Cancer) *Kataka* 90° and *Uttarāyana* in (Capricorn) *Makara* 270°. In 700 A.D. *Uttarāyana* fell on 21st December while in 1600 A.D. on 29th December and at present it comes on 13th or 14th April and occurs in *Ārdra nakṣatra*. Apart from these controversies, it can be stated that in the time of *Vedānga jyotiṣa* (3000 B.C.), the year started (*Uttarāyana*) in or after winter solstice.

In Tamiḻnāḍu, Kerala, Bengal and Punjab, the year starts with *Meṣa Sankrānti* which falls at present on 13th or 14th April. 50 years ago, it was in April 11th, and 5000 years ago, if any reckoning has been kept, it would have begun on 15th February. Actually, the *Kaliyuga* era is said to have started from 18th February in 310 B.C. The commencement of this reckoning can be considered as having started in, at about vernal equinox.

In places like Andhra, Karṇāṭaka and Mahārāṣṭra, where the lunar calculations are observed, the year starts on the first day after new moon on *Caitra* which falls in March, however, in places like Gujarat, the year starts with Diwali following Mahāvīra's *parinirvāṇa* following the new moon day starting with *Kārtik*, which falls in October. They must have followed the autumn equinox for their calculations.

The changes in the dates are due to the precession of the equinoxes. Additions of an intercalary month helps to bring back the seasons to the same position.

The calendars were modified from time to time by experts. Even the present Gregorian calendar has a discrepancy of 0.0079 days or 11 min. 14 sec. longer from the tropical year. In 10,000 years it will amount to a cumulative error of 2 days 14 hours and 14 minutes, but the error is not very significant. This diference would cause the seasons to drift gradually backwards over centuries.

In ancient India, for the eras several reckoning were in use. There were reckonings connected with kings (Vikrama era, Nevari era, Lakṣamaṇasena era) and with religious heads (Jain Nirvāṇa era, Buddhist Nirvāṇa era).

Though our literature is abundant with water clock, sun dial and gnomon, so far archaeologist have not unearthed in any of these things. On the other hand in Egypt the sun dial, water clock and plumb line dated about 500 to 1500 B.C. and the decorations on the tomb of Sermut 1500 B.C.)[103] and the calendar on the temple gateway of Kalasasaya at Tiahuanaco[104] are in existence.

Even though the Western calendar and time measusements have come into practical use in the country, each era in India still adopt their own regional calculations in their almanacs for following their religious practices.

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CHART I

Āryabhaṭīyhm (499 A.D.) Brahmasphūta Siddhānta (628 A.D.)	Vaṭeśvara Siddhānta (880 A.D.)	Siddhānta Śiromaṇi (1150 A.D.)
	100 truṭi = lava (0.0008 sec.)	
	100 lava = nimeṣa (0.08 sec.)	
	4½ nimeṣa = guruvakṣa rochchāraṇakala (0.4 sec.)	
	4 guruvakṣaro chcharaṇakala = kaṣṭha (1.6 sec)	
10 guruvakṣaro [illegible] = prāṇa (4 sec.)	2½ kaṣṭha = āśu (34 sec.)	10 guruvakṣaro chchāraṇakāla = āśu (4 sec.)
[illegible] = vināḍi (24 sec.)	6 āśu = palam (24 sec.)	6 āśu = palam (24 sec.)
[illegible] vināḍi = nāḍi (24 min.)	60 palam = ghaṭika (24 min.)	60 palam = ghaṭika (24 min.)
60 nāḍi = dinam	60 ghaṭi = dinam	60 ghaṭi = dinam

CHART II

Manu and Visṇupurāna (3rd century B.C. to 2nd century A.D.)	Arthaśāstra (100 B.C. to 2nd century A.D.	Bhāgavata and Brahmapurāna (600 A.D. to 1030 A.D.
		2 paramāṇu=aṇu (0.000056 sec.)
		3 aṇu =trasareṇu (0.000167 sec)
		3 trasareṇu=truṭi (0.0005 sec)
	2 truṭi =lava (0.06 sec) (0.12 sec)	100 truṭi =vedha (0.047 sec.)
		3 vedha =lava (0.142 sec)
	2 lava =nimeṣa (0.24 sec)	3 lava =nimeṣa (0.427 sec)
		3 nimeṣa =kṣaṇā (1.28 sec)
18 nimeṣa =kāṣṭha (0.2 sec) (3.25 sec)	5 nimeṣa =kasṭha (1.2 sec)	5 kṣaṇa =kāṣṭha (6.4 sec)
30 kāṣṭha =kalā (1.6 min)	30 kāṣṭha =kalā (36 sec)	15 kāṣṭha =laghu (96 sec)
	40 kalā =nālika (24 min)	15 laghu =nālika (24 min)
30 kalā =muhūrta (48 min)	2 nālika =muhūrta (48 min)	2 nālika =muhūrta (48 min)
30 muhūrta =(day) (dinam)	30 muhūrta =(day) dinam	30 muhūrta=(day) dinam

Gaṇitasārasangraha (850 A.D.)	Siddhānta śekhara (1040 A.D.) Siddhānta śiromaṇi (1150 A.D.) Sūryasiddhānta	Nyāya kaṇḍali (9th century A.D. to 10th „ A.D.)	Abhidhānacintāmaṇi (11th century A.D.)
2 paramāṇu=āvali			
no. of āvali=uchchvāsa (0.75 sec)			
7 uchchvāsa=stoka (5.3 sec)	100 truṭi=tatpara (0.00003 sec) (0.003 sec)	2 kṣana=lava (0.085 sec)	
7 stoka=lava (37.4 sec)			
	30 tatpara=nimeṣa (0.09 sec)	2 lava=nimeṣa (0.17 sec)	
	18 nimeṣa=kaṣṭha (1.6 sec)	18 nimeṣa=kaṣṭha (3.2 sec)	36 nimeṣa=kaṣṭha (0.265 sec)
	30 kāṣṭha =kalā	30 kaṣṭha=kalā	30 kaṣṭha=kalā
			30 kalā=kṣana (4 min)
38½ lava=ghaṭi (24 min)	30 kalā=ghaṭi (24 min)		6 kṣana=ghaṭika (24 min)
2 ghati=muhūrta 48 min)	2 ghaṭi=muhūrta (48 min)	30 kalā=muhūrta (48 min)	2 ghaṭika= muhūrta (48 min)
30 muhūrta=(day) dinam	30 muhūrta=(day) dinam	30 muhūrta=(day) dinam	30 muhūrta=(day) dinam

7

Conclusions

IN the foregoing chapters, the various measures—linear, area, cubic, weights and time—used in ancient India were traced chronologically from the smaller units to the larger ones. In tracing these, efforts were made to indicate (i) the way in which the concepts of these measures evolved through various periods; (ii) the influence of the other civilizations on this evolution; and finally (iii) how in different regions at the same period and also in the same region at different periods, the values associated with the measures of the same name differed. To a cursory reader the information available in the literature and epigraphical records on these measures, cannot but lead to confusion and make him come to the conclusion that there was no uniformity in mensuration concepts in ancient India and that in the development of these measures, no definite system or approach was existing in the past. A critical examination of these, however, will bring out the facts that there was an undercurrent of unity in the development of concepts relating to these measures, even though in the final forms of practical usage, different regions followed different practices associated with local traditional usages. Even today, in spite of the standardization rules relating to the various measures, the traditional usages in different regions continue to be in vogue.

For example calculations of time in the astrological works and also for use in almanacs, still the units of time like *nāḷika*, *muhūrta*, etc., are used. With minor variations all over India, use of these terms are common to fix the dates for religious rites, for casting the horoscopes, etc. Some of the land measures like chain lengths, special rod lengths, terms like *kāṇi*, *guntha*, etc., are also in regular local usage.

The cubic measures like *paḍi*, *nāḷi*, *pāili*, etc., are also in use in different areas, though the actual quantity connoted by these terms, still differ in different regions. It looks as if the original concepts regarding all these measures had a common origin, which in course of time due to variations in usage arising out of local needs and habits got modified into a sort of a local system of measures, which were understood by the local people. Since the trading was well known within the country and also with countries abroad, people must have been aware of the equivalents of these measures in different regions.

This feature is not unusual only for the measures in ancient India. This same feature can be seen in an aspect of this huge subcontinent, such as culture, language, food habits, clothing habits, etc., where there is apparently marked differences in different regions, but still maintaining an undercurrent of unity in all these also. This feature is the natural sequence of the vastness of the country, with exposures to various cultural influences both from within and from abroad and also to a considerable extent to the ethnic differences in different parts of the country.

The linear measures, which are the earliest to evolve, have their origins in relation to the human limbs, since they provided the most easily available standards to a reasonable extent and fulfilled the limited practical needs. In almost all parts of India the *aṅgula* as a concept constituted the most practical smallest linear measure. The *hasta* (cubit) was another widely used measure and from these, the other larger units got derived. Though these measures normally related to the man of average build, since there can be some variations in the size of individuals, variations did come in. In some regions this was standardized to some extent by trying to fix the dimensions relating to a particular individual (local chief,

king or the local deity). In addition to this varying factor, another concept in all these measures also added to the confusion. There was a tendency to adopt three different quantum of value for different measures depending upon the use to which the measure will be applied. The *Vāstuśāstras* mention three different kinds of *aṅgulas* namely *kaniṣṭha* (small) *madhyama* (medium) and *uttama* (large). Similarly the length of the rod or *daṇḍa* varied in measuring the lands given to Brāhmans, measuring furniture and for measuring forests. The king or chieftains had their own measuring rods. These remind one of the Biblical measures such as the length of the cubit for the tabernacles being different from common cubit. The Jews had a common cubit, sacred cubit, as well as a Royal cubit. Though in 20th century A.D., these appeer to be odd and is difficult to equate them with modern measures, these appear to have been well understood by the people of those times and have been well recorded in the literature and epigraphs. The monographs on *Vāstuśāstras* have provided sufficient information to the artisans and masons to create cities and various construction without difficulty. In Mohenjo-daro, the well formed baths, roads, the buildings etc., clearly indicate that the people had their own standards for measurements, without which, such constructions would not have been possible.

For longer distances, Indians used the measures *gavyūti* or *krośa*, which is the distance from which the bellowing of a cow or human voice can be heard and *yōjana*, which is the yoking distance in a day or walking distance within a certain time. These sort of measurements were in vogue in other countries also. Chinese *li*, which is considered in text books as ⅓ of a mile, is actually the distance covered by a coolie with a standard burden. He is expected to cover so many *li* per day according to the nature of the country and such coolie day stages are all in multiple of 10 *li*. In parts of China, where there are no reliable maps the *li* distances are known. Every 10th *li*, there was a stage posts, at which the coolies used to take rest, roughly one rest every hour. In mountainous countries, the stage posts are closer, though in the Chinese view, they are still 10 *li* apart. From the commercial point of

view, the calculation of the distance in terms of time appears to be logical. In mountain regions, notably Alps, guides give distances in terms of hours.

Areas were measured by the *daṇḍas* or by the amount of seeds required for sowing or by the yield of the land (kulyavāpa etc.). This is like the word acre, which was originally applied to an enclosed land without any specific measurement. It came to mean an area ploughed in a day by a yoke of oxen. On poor light soils, the area of an acre would exceed than that on rich heavy soils. The expected yield from the two types of acres was roughly the same. In South-East Asia the cultivators measure the area of their rice fields, by the number of baskets of seed sown in it. The quality of the land is stated, in terms of the number of baskets of paddy they expect to harvest, compared with the number sown. Thus a 3 basket field of 50 baskets land, will yield in an average year, 150 baskets. The former is interested in knowing about the seed required for sowing and the yield, rather than geometry. This was simple and sensible to him though it gave no indication of the area of the land. This same principle applies to the Indian area measures like *kulyavāpa*, *drōṇavāpa*, etc. Hence to calculate them with modern measures will be difficult.

Great accuracy in weighing precious metals and stones was developed. The use of the seeds of uniform size, which was in vogue in ancient India and other places continue to be in use even today among the jewellers. The common balance as well as one-pan balance depicted in coins and sculpture, indicate that weighing was a common phenomenon among traders.

The intimate connection between the coinage and the weight system is also well known. The standard unit of precious metals became the standard units of value and this became the coin, when stamped with the royal insignia. Some of the names of the coins indicate this relation in many cases. However, later on as the values of the metals varied, the face value of the coins became different from their intrinsic values.

In spite of the regional variations for weighing articles other than precious metals, the terms *palam*, *viss* and *man* (*manaṅgu*, *manaṅgulu*), seem to be in usage in several parts of

India. *Man* is a derivation from the Sanskrit word *'māna'*, to measure. The weight it represented varied in different periods in different areas. Even in Mughal India, *man-i-Akbari* weighed 55.32 lbs, while *man-i-Shah Jehani* weighed 73.76 lbs. For weighing large bulks the terms like cart-load, ass-load and head-load were used in the past and continued still in certain places.

It appears that the cubic measures were often interlinked with weights. Since, primarily the grains were measured, the volume measures must have been equated with the weight of the amount of grain which a particular vessel can deliver. The hollow vessels used for measuring grains, oil, etc., must have had some relationship to the weight also. For example *muṣti*, which is the most convenient form of measure to give alms, gifts of grains, etc., is equated with the *pala*. Approximately a *muṣti* of paddy is found to be about 60 c.c. and weighs 32 gms. Several writers have often equated volume measures like *āḍhaka* and *drōṇa* with several *pala* which is a weight measure and this indicates that cubic measures were interlinked with gravitational measures. It is not out of place to mention here that the ounce of the present day when it is used as a cubic measure is nearly 28.5 cc. and it is 28.5 gm taking into consideration the fact that 1 cc. of water at 4°C is equal to 1 gm in weight. In the past in India also a similar idea must have been adopted.

As in the case of varying values for *man*, in South India, the *nāḷi* and *paḍi* varied during the regime of different kings. *Aruḷmoḻidevan nāḷi* the standard of Parakesari Rajendra Coḷa, was smaller than that of *Rājakesari nāḷi*, the standard of his father Rāja Rāja. That is $1\frac{3}{8}$ of *Aruḷmoḻidevan nāḷi* would measure 1 *nāḷi* of *Rājakesari*. These differences might perhaps be due to the change in the prosperity of the country.

Temple measures were also different in many regions. Generally the measures in a particular region was the measure used in the temple of that place. *Ādavallān nāḷi* refers to the temple measure of Cidāmbaram which was current in that place.

All these somewhat resemble the concepts relating to the *shekel* of the sanctuary (Exodus 38:24), *shekal* of the king (Samuel 34:26), etc., mentioned in the Bible, showing different weight standards of Jews of that time.

Time is a recurring cycle, in which the events repeat themselves in periodic sequence. This recurring cycle is the result of the rotation and the revolution of the heavenly bodies. Hence, just like the other corresponding civilizations, natural phenomena were taken into account. The keen observations, particularly in relation to the planetary and stellar movements lead to a system of time measure, which enabled ancient Indians to predict exactly several phenomena like eclipses, meteors etc. For minute details, the duration was calculated by the cracking of the finger, wink, etc. These developed into bigger units leading finally to exeligmos like *kalpa*, *manvantara*, etc.

Without the modern sophisticated equipments, development of accurate systems to calculate them, indicates the great observation power and skill of our ancient matbematicians and astronomers about which our Nation can feel proud of. To quote an example, the 5th century astronomer Āryabhaṭa suggested that the planets including the earth revolved round the Sun. But the credit for expounding this heliocentric theory is attributed by the Western scientists to Copernicus, who expounded this theory in 16th century A.D.

No doubt the various measures mentioned above were not standardized as in the twentieth century A.D. In modern era, the standard of length may be defined as the distance under specific conditions between two parallel lines, engraved upon a material standard bar (line standard), or between two flat and parallel end surfaces of such a bar (end standard). Compared to this, the ancient standards look somewhat crude and absurd, and not scientifically exact or precise, but were easier to use and understand. If the criterion for good scale is for convenience, then the primitive measurements are convenient in their socio-economic context.

Finally the quaternary system appears to have been quiet prevalent. Though the archaeologists have suggested the existence of decimal system in weights, as far as literature is concerned mainly quaternary or binary systems are seen in relation to mensuration.

APPENDIX-1

YOJANA FROM DIFFERENT SOURCES

1. According to Kauṭilya 4,000 *dhanus* or 384,000 *aṅgulas* is a *yojana*.

$$\frac{384,000}{1760 \times 12 \times 3} = \frac{200}{33} = 6{,}06 \text{ miles (9.7 km.)}$$

2. If the *aṅgula* is considered as $\frac{3}{4}$ of an inch, than it will be:

$$\frac{200}{30} \times \frac{3}{4} = 4.54 \text{ (7.3 km.)}$$

3. If Bhaṭṭasvāmin's interpretation is taken, the answer for no. 1 and 5 will be double, i.e., 12.12 miles (19.5 km.) or 9.09 miles (14.58 km.).

4. According to Purāṇas, Mahāvīra, Śrīdhara, Bhāskara and Jaina canonical literature 768,000 *aṅgulas* make one *yojana*

$$\frac{768,000}{1760 \times 3 \times 12} = \frac{400}{33} = 12.12 \text{ miles (19.5 km.)}$$

If the *aṅgula* is considered as 1″.

$$\frac{400}{33} \cdot \frac{3}{4} = \frac{100}{11} = 9.09 \text{ miles (14.58 km.)}$$

If the *aṅgula* is considered as $\frac{3}{4}$″.

5. The Kannaḍa writer Rajāditya considers 76800 *aṅgulas* as a *yojana*. Hence, his *yojana* measures 1.21 or 0·9 miles (1.93 or 1.08 km).

6. In *Samarāṅgaṇasūtradhāra*, 106×1000×8 *aṅgulas* are mentioned as *yojana*.

$$\frac{1000}{33} \times \frac{8}{12} \cdot \frac{106}{1700} = \frac{1325}{99} = 13.3 \text{ miles (21.4 km.)}$$

considering *aṅgula* as 1″.

7. In the Bakśali manuscript, though 768,000 *aṅgulas* are considered as *yojana*, an *aṅgula* measures 6 *yavas* or $\frac{3}{4}$″. Hence,

$$\frac{768,000}{1760 \times 3 \times 12} \times \frac{3}{4} = \frac{100}{11} = 9.09 \text{ miles (14.58 km)}$$

make one *yojana*.

APPENDIX-2

Extract from the "Manual of the Administration of the Madras Presidency Vol. III—Glossary, 1893; p. 17.

Weights and measures in the 19th century

Kanarese

4 seer	= solage
16 solage	= balla
16 balla	= kolagam
20 kolagam	= khandiga
14 seer	= kalsi
3 kalsi	= mudy

Telugu

4 gidda	= sola
2 sola	= tavva
2 tavva	= kunchamu
4 kunchamu	= tumu (6 lbs-4 ozs)
20 tumu	= putty

Malabar

10 yadangazhi	= parrah
1 yadangazhi	= 113$\frac{3}{4}$ c inches

Madras

10 pagoda	= palam = 3 tola
8 palam	= seer (9 oz 10 drams)
5 seer	= viss (3$\frac{1}{8}$ lbs)
10 seer	= dhadiyam
8 viss	= maund (25 lbs)
10 maund	= pothy
2 pothy	= baram

2 gundumani	=	manjadi
20 manjadi	=	kalanju
44 manjadi	=	1 rupee (180 grains)
12 kalanju (5½ tolas)	=	palam
100 palam	=	tulam

Trichy

3 tola	=	palam
8 palam	=	kutcha seer
5 kutcha seer	=	viss
25 palam	=	pukka seer
8 pukka seer	=	tulam (15.4 lbs)
32 tulam	=	candy (403 lbs)

Cubic measures

In cubic measures, generally the contents in cubic inches of any heaped measure, is the weight in heaped measure and generally rice or 9 sorts of grains are used. It has been found that raw rice averages 113 tolas weight to 100 c. inches. Madras measure is 117 tolas weight when stuck and 128 tolas when heaped. The volume of the Madras measure is 104 c. inches when heaped.

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Juna stone inscription of Samantasimhadeva (Vikrama) Samvat 1352, *EI* XI, p. 59.
Bhattacharya, Dineshchandra, A newly discovered covered plate from Tippera (The Gunaigarh grant of Vainyagupta; the year 188 current (Gupta era), *IHQ*, 1930, p. 45.
Desai, P. B. Godachi plate of Kattiarasa, year 12, *EI*, XXVII, p. 54.
Gokarṇa plates of Kadamba Kāmadeva, Saka 1117, *EI* XXVIII, p. 157.
Fleet, J.F. Eran stone pillar inscription of Budhagupta, the year 165, C.I.I. III no. 19.
Maliya copper plate inscription of the Mahārāja Dharasena II, *CII* III No. 38.
Yekkeri rock inscription of the time of Pulakesin III, *EI* V, p. 17.
Chammak plates of the Maharaja Pravarasena II, *C.I.I.* III no. 55.
Sanskrit and old Canarese inscriptions, *IA*, IV, p. 279.
Sanskrit and old Canarese inscriptions, *IA* VI, p. 109.
Sanskrit and old Canarese inscriptions, *IA* VI, p. 126.
Sanskrit and old Canarese inscriptions, *IA* VII, p. 33.
Sanskrit and old Canarese inscriptions, *IA* VIII, p. 23.
Sanskrit and old Canarese inscriptions, *IA* XI, p. 102.
Sanskrit and old Canarese inscriptions, *IA* XIX, p. 18.
Inscriptions from Managoli *EI* III, p. 23.
Two Chera Grants *IA* XVIII, p. 109.
Bombay Asiatic Society's copper plate grant of Bhīmadeva II, Simha Samvat, 93, *IA* XVIII, p. 108.
Inscriptions relating to the Ratta chiefs of Saundatti and Belgaum, *JRAS* X p. 199.
A stone inscription of the Sinda family of Bhairampatti, *EI* III, p. 230.

Gupta, K.M. The Bhatera copper plate inscription of Govinda Keśava deva, *EI* XIX, p. 277.
Ganguly Dhiren Chandra, Śaktipur copper plate of Lakshmaṇa-sena, *EI* XXI, p. 21.
Halder, R. Dharavarsha Paramāra and his inscriptions, *IA* LVI, p. 50.
Hiralal Rai Bahadur, Four Chandella copper plate inscriptions (from Charkkari) Mahoba plates of Paramardideva (Vikrama Samvat 1230). *EI* XVI, p. 9.
Hultzsch, E. The two inscriptions of Vāillabhaṭṭaswāmin temple of Gwalior, *EI* I, p. 154.
Mayidavolu plates of Sivaskandavarman, *EI* VI, p. 88.
Chandalur inscription of Kumāravishnu II (year 2), *EI* VIII p. 233.
Sunak grant of Karṇa I, dated V. S. 1148, *EI* I, p. 316.
Ganeshghad plates of Dhruvasena I (Gupta) Samvat 207 *EI* III p. 318.
Iyer Subramania, K.V. Three Tamil inscriptions from Lālguḍi *EI* XX, p. 46.
Pirimiyam inscription of the 20th regnal year of Konāttan Vikrama Chola *EI* XXX p. 105.
The Tirumukkūdal inscription of Vīrarājendra, *EI* XXI p. 220.
Iyer Venkatasubba, V. Tāli inscription of Koḍai Ravi, *EI* XXXIII, p. 216.
Kielhorn, F. Junagadh rock Inscription of Rudradāman, *EI*, VIII, p. 36.
Paiṭhan plates of Govinda III, S.S. 716, *EI* III, p. 109.
Nilgund inscription of Taila II S. S. 90, *EI* IV p. 204.
Kolhāpur inscription of Śilāhāra Vijayāditya S.S. 1065, *EI* III, p. 207.
Kolhāpur inscription of Śilāhāra Bhoja II, Saka Samvat 1112-1115, *EI* III, p. 213.
Rajor inscription of Mathanadeva (Vikrama) Samvat 1016, *EI* III, p. 263.
Chamba copper plate inscription of Somavarmadeva and Asatadeva, *IA* XVII, p. 7.
Dubhund stone inscription of Kachchapaghata Vikrama-simhadeva the (Vikrama) year 1145, *EI* II, p. 232.

Copper plate grant of Madanapāla and Govinda chandra deva (Vikrama) year 1166, *IA* XVIII p. 16.
Pāli plates of Govindachandra and his mother Ralhaṇadevi (Vikrama) Samvat 1189, *EI* V, p. 113.
Chebrolu inscription of Jaya S.S. 1157, EI VI, p. 39.
Siyadoni stone inscription (Śāntinātha temple) (960-1025), *EI*, I p. 162.
Copper plate grant of Mahārāja Yaśovarmadeva (Vikrama) year 1192, *IA* XIX, p. 438.
Harsha stone inscription of Chāhamāna Vigraharāja, E*I* VI, p. 116.
Banda district plates of Madanavarmadeva (Vikrama) Samvat 1290, *IA* XVI, p. 206.
Kielhorn, F. and Krishnasastry, Salotgi pillar inscription, *EI* IV, p. 52.
Mahalingam, T.V. Two eastern Ganga inscriptions from Kānchipuram, *EI* XXXI, p. 95.
Mirashi, V. V. Dudia plates of Pravarasena II, *C.I.I.* V no. 10.
Chammak plates of Pravarasena II *C.I.I.* V, no. 6.
Wadgaon plates of Pravarasena II *C.I.I.* V, no 12.
Paṭṭan plates of Pravarasena III *C.I.I.* V, no. 13.
Abhona plates of Sankaragaṇa (Ralachur) VI year 347 *C. I. I.* IV, part I, no. 12.
Sarasvāṇi plates of Buddharāja: year 361, *C.I.I.* IV, pt. I, no. 15.
Spurious Kavi plates of Vijayarāja (Kalchuri) year 348 *C.I.I.* IV, pt. I no. 34.
Maity and Mukerjee Dhānaidaha copper plate inscription of Kumāragupta (A.D. 432-439) *C. B. I.* no. 4.
Bāigrām copper plate inscription of the Gupta year 128 (1148 A. D.) *C.B.I.* no. 7.
Pāhārpur copper plate of the Gupta year 159 (479 A. D.) *C.B.I.* no. 8.
Dāmodarpur copper plate inscription of Budha Gupta (476-495 A.D.) *C.B.I.* no. 10.
Faridpur copper plate inscription at the time of Dharmāditya" *C.B.I.* no. 14.
Belāva copper plate of Bhojavarman, 12th century A.D.

C.B.I. 35.
Mādhāinagar copper plate of Lakṣmaṇasena (12th century A.D.) *C.B.I.* no. 39.
Tarpandigi copper plate of Lakṣmaṇasena (12th century A.D.) *C.B.I.* no. 41.
Ānulia copper plate of Lakṣmaṇasena (12th century A. D.) *C.B.I.* no. 42.
Sunderban copper plate of Lakṣmaṇasena (end of the 12th century) *C.B.I.* no. 48.
Ojha, R.J., New plates of King Bhoja in the Indore Museum (Vikrama) Samvat 1079, *IHQ*, VIII, p. 304.
Partabgarh Inscription of the time of (Pratihāra) King Mahendra II of Mahodaya V. S. 1003 *EI* XIV p. 176.
Pargiter, F.B., Three copper plate grants from East Bengal, *IA* XXXIX, p. 199.
Pathak, K.B. Abhona plates of Śankaragaṇa Kalachuri Samvat 347, EI IX, p. 57.
Pandit Shankar Pandurang Translation and remarks on a copper plate grant discovered at Tidgundi, in the Kalaḍgi Zilla *IA* I, p. 80.
Rajabali Pandeya, 13th inscription from Shahbazgarhi cave Aśokan Abhilekhan no. 13.
Ramamurthy, G.V. Konkuduru plates of Allaya Dodda, S.S. 1352, *EI* V. p. 53.
Randle, H.N, India Office plate of Lakshmaṇasena *EI* XXVI, p. 1.
Rice Lewis, Penukoṇḍa plates of Mādhava II (III) *EI* XIV p. 331.
Sastry Krishna, Mindigal inscription of Rājādhiraja S.S. 970 *EI* V p. 205.
Sastry Visveswar Nath, Hathal plates of (Paramāra) Dhārāvarsha (Vikrama) Samvat, 1237, *IA* XLIII, p. 192.
Senart, E., The inscriptions in the caves of Kadi, *EI* VII p. 64.
The inscriptions in the caves of Nasik, *EI* VIII, p. 71.
Two Sailodbhava grants from Banpur, *EI* XXIX, p. 33.
Sircar, D. C., Nagari plates of Ananga Bhima III, Saka 1151-1152 *EI* XXVIII, p. 235.
Janvara inscription of Chāhamāna Gajasinghadeva and Kelhaṇadeva (V. S. 1218) *EI* XI, p. 277.

Two Ikṣvāku inscriptions dated in the cyclic year Vijaya *EI* XXXC p. 1.
Patanārāyana stone inscription of Paramāra Pratāpa simha (Vikrama) Samvat 1344 *IA* XLV, p. 177.
Three plates from Pāndukeśwar (plate-3) plate of Subhiksharājadeva regnal year 4, *EI* XXXI p. 291.
Kendupaṭna plates of Narasimha II, Saka 1217 *EI* XXVII, p. 17.
Alagum inscription of Anantavarman, regnal year 62, *EI* XXIX p. 44.
Sircar D. C. and Sten Konow, Mathura Brahmi inscription of the year 28, *EI* XXI p. 55.
Sten Konow, Five Valabhi grants (Pālitana) *EI* XI, p. 104.
Venis Arthur, Pachar plates of Paramārdideva, V.S. 1133, *EI* X, p. 43.
Vogel, J. Ph., Prakrit inscriptions from a Buddhist site at Nagārjunakoṇda; *EI* XX, p. 21.

Index

ERRATA

Page	Line	For	Read
21	38	plates	places
23	27	Gunders'	Gunter's
32	42	EL	EI
33	3	EL	EI
49	29	Cintamani	cintāmaṇi
57	17	Yaksaraya	Yaksārya
57	22	Patiganita	Pātigaṇita
92	24	drona	droṇi
108	11	Mānasoliāsa	Mānasollāsa
112	28	Manasollasa	Mānasollāsa
115	11	Katyayanasrautāsutra	Kātyāyanasrautasūtra
119	10	man	men
130	28	religions	religious
131	11	Sardulakarnadana	Sārdūlakarṇavadāna
133	14	comprises 15 days	comprises of 15 days
135	35	State	state
138	4	Rathanjaia	Rathanjala
149	11	on	or
154	6	archaeologist	archaeologists
155	17	era	area
164	36	posts	post